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The sponsors of the conference express their appreciation to those who appeared on the program and to the many others who contributed time and effort to planning the conference.

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SOYBEAN PRODUCTS FOR PROTEIN IN HUMAN FOODS

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CONFERENCE ON SOYBEAN PRODUCTS FOR PROTEIN IN HUMAN FOODS

Introductory Remarks

By Dr. F. R. Senti

On behalf of each of the sponsoring organizations, I take pleasure in welcoming you to this conference on the use of soybean products for protein in human foods.

There are two main reasons why this is an appropriate time for such a conference: First, there is a large and growing need for low-cost, high-quality protein in the diets of the developing countries of the world; and, second, the soybean offers opportunity for contributing importantly to this need.

We are all aware of the phenomenal expansion of the soybean crop--from a little less than 14 million bushels in 1930 to an estimated production of over 700 million bushels for this year's crop. Expansion of the crop during this period has changed the United States from a net importer of fats, oils, and oilseeds to a net exporter of these products.

The rise in soybean production has resulted in soybean oil becoming the major source of edible fats in our food supply. The economical and nutritionally efficient protein supplied by soybeans has been responsible in large measure for the expansion of our poultry and livestock industries. A developing use, although now relatively small in this country, is that of soy flour, grits, and isolated protein in food products. In addition, we have exported both soybeans and soybean products to meet needs for oil and meal abroad, and--in the case of Japan, especially--to supply food protein as well. Indeed, in each of the past 2 years, we have exported over 140 million bushels of soybeans, about 1 billion pounds of oil, and 1/2 million tons of soybean meal. With the larger crop of the current year and the predictions of many for still greater production in future years, larger quantities of soybeans and soybean products should be available to meet the needs of other countries.

With this favorable prospect for the soybean supply, it is timely to consider how this important source of protein and oil can best supply world diet deficiencies in essential protein as well as edible oil.

The purpose of this conference is to review the need for protein in world nutrition and to discuss the contribution which soybean products can make to supply this need. The subjects and speakers have been selected to give a comprehensive view of food products now made

from soybeans, both in this country and abroad; to present a critical review of current status of knowledge of the nutritional value of soybean protein; and to discuss work which needs to be done to adapt soybean products to the food habits and customs of people in various parts of the world.

As General Chairman of this conference, I want to express my personal appreciation and thanks to the sponsoring organizations whose help in planning and organizing this conference has made my task an easy one. Many have contributed much time and effort to plan the details of the program. I give special thanks to Dr. Max Milner of United Nations Children's Fund; Dr. J. W. Hayward, Soybean Council of America; Mr. Gleason M. Diser, Soybean Research Council, National Soybean Processors Association; and Dr. Allan K. Smith and Dr. John C. Cowan of this Division. Their cooperation was most valuable in setting the objectives of this conference and the areas to be discussed to accomplish these objectives.

Session I

NUTRITIONAL DEFICIENCY PROBLEMS IN DEVELOPING AREAS OF THE WORLD

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WORLD ASPECTS OF PROTEIN MALNUTRITION

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There seems little doubt that protein malnutrition is the most widespread form of deficiency disease in the world today. Although nutritional anemia, goitre, and the various vitamin deficiencies continue to be major problems for certain segments of the population, from a world viewpoint, protein malnutrition far exceeds these in importance.

There is increasing evidence that protein malnutrition accounts for a major part of the deaths of children between weaning and school age in many parts of the world. This situation has been recognized only in recent years because the effects of the deficiency have been complicated and hidden by the occurrence of infectious diseases. Scrimshaw has recently pointed out that it is necessary to consider not only the effect of nutrition on infections but also the effect of infections on nutrition. Thus, protein malnutrition may result in the death of a child from an infectious disease from which it would not have died had its nutritional status been known. On the other hand, infections along with other stresses seem to act as precipitating factors in the onset of severe protein malnutrition or Kwashiorkor. Thus, the child may die either from the malnutrition or from the effects of the infection, although the basic problem is in each case protein malnutrition.

From a world viewpoint, it is necessary that agricultural programs be directed not only toward increasing yields but they also must be oriented toward increasing and improving the protein supply. It is no longer enough to urge just the production of more food. We must at the same time attack the infinitely more complicated problem of influencing the kinds of foods that are produced in a direction which will increase the protein. The situation is further complicated by the rapidly increasing world population which is already posing a problem of increasing the food supply to keep up with the population growth. If we succeed only in this objective, we cannot hope to improve the present distressing situation in regard to protein malnutrition. It is, of course, essential that caloric needs receive first consideration. However, an acute and severe deficiency in calories produces famine which quickly leads to the death of large numbers of people and results in immediate emergency remedial measures. However, of even greater importance is a long continued partial caloric deficiency. This is so closely tied to the need for protein that the two must be considered inseparable from a practical point of view.

The synthesis of specific proteins in the body from amino acid fragments requires energy. Presumably the source of this energy is the high energy phosphate bonds obtained from the fat and carbohydrate in the diet. It is well known that an insufficient supply of calories results in the inefficient use of protein. Since the basic calorie needs of the body receive first consideration, if there are not enough calories available from other foods, some of the protein food must be utilized for energy. This means that protein is inefficiently used in the presence of a restricted supply of calories. Furthermore, proteins are the only group of basic food substances that furnish nitrogen which is essential for the growth, development, and replacement of tissues. They are, therefore, of the greatest importance to growing children. Proteins are necessary also for another peculiar reason. Chemically they are formed by long chains of amino acids which are tied together in an infinite variety of ways. The body utilizes these proteins by breaking them down into their amino acid fragments, of which there are 18 which commonly occur in our foods. The body is able to manufacture all of these, with the exception of 8 which are, therefore, known as the essential amino acids. A deficiency in a food of one or more of these 8 amino acids which the body cannot manufacture determines to a large extent the value of the various protein foods. This leads to the necessity of considering not only an increase in the world's protein supply but this increase must be brought about in such a way that the needed essential amino acids are supplied in adequate amounts.

Man must have not only enough protein food but this protein food must have the right amino acid composition and these amino acids must be available in the right proportion at the right time. The problem is a very complicated one because of the fact that we are dealing with a large number of possible interrelationships between amino acids as well as the total amount of nitrogen and the total amount of food energy available to the individual. It is very difficult to determine the optimum level of protein and although we do not today know what this figure may be, we still know enough so that from the practical application of what we do know we can make enormous improvements in the health of the world.

For many years nutritionists tried to meet the intricacies of the problem by specifying not only a total amount of protein for an individual but also by saying that a certain proportion should be from animal sources. This is a handy, but crude and uncertain way of approaching the problem and in areas in which the protein supply is short, it could result in the wasteful use of high quality protein. The separation of protein foods into those of animal origin and those of plant origin merely reflects the fact that animal protein usually furnishes a better supply of the essential amino acids while the cereal and vegetable proteins are deficient in one or more of them and, therefore, have a lower biological value (see Table 1).

Table 1.--Protein inadequacy of staple foods for adults

(Based on adult male weighing 60 kilograms requiring 31.5 grams daily of protein with biological value of 100)

Food	Protein content g./100 g.	Calories per 100 g.	Estimated protein score	Daily protein requirements, grams	Protein accompanying 2,000 cal. intake
Rice	7	363	72	44	39
Maize	9	355	42	75	48
Wheat (whole grain)	12	332	59	53	72
Millet-sorghum	10.5	331	68	46	63
Cassava	1.1	131	22	143	17

However, it is well known that a completely adequate protein supply can be obtained solely from vegetable sources, if the supply of essential amino acids is carefully looked after.

One way of getting the greatest usefulness of the world's supply of high quality protein from animal sources is to dilute them with proteins of lower biological value from other sources. Fortunately, this procedure is naturally used almost universally with a large variety of food combinations. This provides a base on which to build new and acceptable mixtures. A few examples are spaghetti and cheese, rice and fish, bread and milk, chili beans and meat. I am sure all of you can think of many other examples.

The most effective use of the high quality protein foods is obtained by mixing and diluting them with a variety of other foods containing protein of lower biological value. We must increase the world supply of animal proteins and promote the use of animal protein products to the limit. This will still leave a large proportion of the world's population in a state where animal protein products are either too expensive or are unobtainable at any price because of various soil, climate, and economic factors. In these areas all other sources of possible protein foods must be explored.

The prospective world supply of important protein foods may be put into five classes of products:

1. Animal products
2. Marine products
3. Cereal grains
4. Oilseed press cakes
5. Legumes

Protein foods of animal origin are preferred by most of the world's population, except where religious or social factors intervene. On the whole, one can anticipate little difficulty in increasing the supply of these products where it is economically feasible. However, we can perhaps facilitate this development by careful planning. For example, there is a possibility in Africa of using low grade cattle to make a meat powder. A careful study of the problems involved might reveal that it is economically feasible to make a similar product in other parts of the world. The extension of the egg and broiler type of chicken production which has been so successfully developed in this country could result in a greatly increased availability of high quality protein foods in areas such as Latin America and the Middle East.

Marine products have always created special problems because of the need for refrigeration and rapid handling. Therefore the economic problems have largely confined their use to areas close to the source of supply. The extension of fish pond culture so successfully used in China and the cultivation of fresh water fishes in irrigation canals and basins could extend the supply of these products. It also appears that there are large areas of available fish in the oceans which have not been exploited. It must be recognized, however, that the fish in the oceans develop in large numbers only where their food supply is adequate. Therefore, the oceans do not constitute an endless supply of marine food. The greatest possibility in this area lies in the production of a suitable fish flour which could be stored without refrigeration and with little odor and taste, which would make it suitable for mixing with other foods. The natural tendency of the industry is to try to convert the present fish fertilizers or animal food products to human use with a minimum change. Preliminary results in this direction have not been very successful in that the final product is of variable quality and may be of low biological value and would, therefore, fail to serve its purpose as a protein supplement. The problems here appear to be largely economic and technical. A suitable product can be made, and has been made, that will meet the requirements for biological value, taste, color, and odor. Whether it can be produced at a price which will make it economically feasible is the question that remains to be solved. The chances appear to be good.

Even though we produce animal protein foods to the extent of our ability and use marine products to the full extent of their availability, including a suitable fish flour, these products still will not get to the heart of the problem in many parts of the world since they will represent the movement of a food from a highly productive high economic area to an economically poor area of low productivity. The fundamental reason for underdeveloped populations is a lack of productivity. Therefore, the basic problem is how to increase productivity in an underdeveloped poor economic area at the same time that we find a source of protein that can be produced within the resources of such a population.

The three cereal grains--rice, wheat, and corn--really constitute the foundation of the food supply of most of the world. Unfortunately the protein of these three cereal grains is deficient in one or more of the essential amino acids. The problem then is how can the missing essential amino acids be supplied within the resources of the people concerned, if animal and marine protein foods cannot be made available in amounts sufficient to meet the need, and at suitable prices. In trying to solve this problem, it seems that the most logical solution is a mixture of foods of vegetable sources or a mixture with a small amount of added animal protein. In looking for source material for such mixtures, a large group of foodstuffs of relatively high protein value now largely wasted as human food immediately comes to mind. These are oilseed press cakes which are now largely used as animal foods. Fertilizers are completely wasted in many parts of the world because the manner in which the oil is produced does not result in a residue suitable for human consumption or suitable processes for economical recovery have not been developed. The products of greatest importance are: Soybeans, peanuts, and cottonseed. The FAO has estimated that the world production in 1958 of these oilseeds was:

	Million tons
Soybeans.......	28
Cottonseed.....	19
Peanuts........	14

Three other oilseed press cakes are of interest although they are not produced to the same extent. These are:

	Million tons
Copra..........	3
Sunflower......	2
Sesame.........	2

These products usually contain about 40 percent protein and, therefore, represent a wasted resource for human protein food which could be immediately utilized. There are no difficult technical problems in the use of either of the soy, cottonseed, or peanuts. Copra offers a particular opportunity since the problems here are largely in the economics of handling and the technical difficulty in separation. Sesame also presents technical problems in handling. Soybeans are of special importance not only because of their acceptability to many people in the world as an item of food but they can be cheaply produced, adapted to a wide range of soil and climatic conditions, and made into a great variety of acceptable dishes. The protein is also of better quality than that of the other press cakes, although the limiting essential amino acid is methionine. The development of protein food mixtures containing soybeans offers very attractive possibilities for areas where they can be produced or made economically feasible (see Table 2).

Table 2.--Protein and calorie content of selected supplemental foods

	Water per 100 g.	Cal. per 100 g.	Protein per 100 g.	Protein per 1,000 cal.
Animal Products				
Cow's milk, fresh	87.0	66	3.7	56
Cow's milk, dried skim	3.5	362	35.6	82
Buffalo milk	82.2	106	4.7	44
Eggs (as purchased)	66	144	11.4	80
Beef, thin (as purchased)	54	164	15.2	92
Mutton, thin (as purchased)	45.7	142	11.8	83
Pork, thin (as purchased)	41.0	311	11.6	37
Sardines (as purchased)	47.1	175	21.1	121
Codfish (as purchased)	39.6	36	7.9	219
Pulses				
Dry beans (Phaseolus vulgaris)	12.2	336	23.1	68
Dry peas (Piswm sativum)	11.6	339	23.8	70
Broad beans (Vicia faba)	12.2	338	25.4	75
Chick peas (Cicer arietinum)	10.6	359	20.8	57
Lentils (Lens culinaris)	11.2	337	25.0	74
Pigeon peas (Cajanus cajan)	13.1	333	21.9	65
Cow peas (Vigna sinensis)	10.6	342	22.9	66
Field beans (Dolichos lablab)	11.8	338	22.2	65
Mung beans (Phaseolus aureus)	11.0	339	24.4	71
Oilseeds				
Soybean seeds (fat 18.1%)	7.5	331	34.9	105
Soybean flour (fat 6.6%)	8.2	244	38.4	157
Peanuts as purchased in shell (fat 30.4%)	2.8	389	18.6	48
Peanut flour (fat 6.9%)	2.3	327	42.8	131
Sesame seed (fat 51.1%)	5.8	568	19.3	34
Sesame flour (fat 5.7%)	10.9	257	36.7	143

The one remaining world resource for acceptable protein food that could be developed and that appears to be economically feasible is the legumes. There are a multitude of kinds and varieties of legumes grown and used as food in all parts of the world. Although they vary widely in composition, most of them could yield 20 to 25 percent protein and they already are an important source of protein for vegetarians. They, like other protein foods of vegetable origin,

have important limiting essential amino acid deficiencies. However, suitable selection of different varieties and mixtures based on cereal grains make attractive possibilities for human food. There are many problems to be solved in the use of the legumes. Many of them contain highly toxic substances which must be removed or destroyed before they can be eaten. Most of them must be cooked to some extent to improve their nutritive value and digestibility. But, there seems to be no obstacle here that cannot be solved by well-planned research programs based on the legumes available in the area in which the food problem is to be met.

In passing, I want to mention some of the other possible protein sources which may have occurred to you but which offer varying degrees of more serious difficulties. One of these is the possible use of the protein of green leaves, such as alfalfa, grass or similar products. Such products have many drawbacks in color, odor, taste, and biological value. Although research is being done in this area, no suitable product has been produced as yet. The algae have been and are being extensively studied. The economic problems in production and the lack of acceptability of the product still makes this highly experimental. Nuts of varying kinds offer a possible source of protein. These are expensive and usually can be eaten only in limited amounts because of their high oil content. However for some areas it may be possible to develop a suitable product from nuts. The cashew nut seems to offer some possibilities in this area.

Yeast has been the subject of exhaustive study because of its protein content. However, yeast has proven to be acceptable only in limited amounts and, therefore, can be used only as a small part of a mixture. Yeast is also now running into an added complication in this country because of the proposed Food and Drug Administration ruling on folic acid. If the Food and Drug ruling is applied to yeast, the folic acid content of yeast may ban any extended use of it in this country as a food supplement, unless a way can be found to remove the folic acid.

The mold fermentation of soybeans and other products as a method of improving the protein value is under study and may yield worthwhile results. Mold fermentations of this type have been used in Japan and other countries for a long time and their possibilities must be explored.

Finally, a word should be said about the possibilities that lie in the chemical production of essential amino acids. Some of these can be produced in commercial quantities today at prices which make them practical possibilities. The protein of wheat offers a special situation in that supplementation with lysine makes the protein the practical equivalent of milk protein. Although the use of amino acids in food in this way is just in its beginning, it offers great possibilities for the future.

The best known food mixtures that are under study and development in various parts of the world are the following:

Incaparina mixture No. 9 which consists of

	Percent
Corn mesa	28
Sorghum	28
Cottonseed flour	38
Dehydrated leafmeal	3
Tourla yeast	3
Calcium carbonate	1

With added vitamin A

This mixture developed for INCAP primarily for use in Central America has been very thoroughly tested both for its biological value and acceptability. This mixture has been patented by INCAP and is now being licensed by them for commercial production. It illustrates a successful low cost protein mixture of good biological value.

Another product that has received extensive testing is known as Indian Multi-Purpose Food and consists of

	Percent
Peanut flour	75
Bengal gram	25

With thiamine, riboflavin, vitamin A and D, and calcium phosphate added

This is now being produced and given to school children in some parts of India.

A third type of mixture has been used by Dr. Dean in Uganda as a biscuit for school children and contains

	Percent
Dried skim milk	15
Sucrose	12
Cottonseed oil	6
Maize flour	26
Peanuts	41

Dr. Bradfield in Peru has developed a mixture made of

	Percent
Cottonseed flour........	30
Quinuia.................	10
Habas...................	10
Achita..................	10
Alfalfa leafmeal........	2
Torula yeast............	2
Wheat flour.............	35

This mixture is still under study.

Dr. Wei in Taiwan has been experimenting with a mixture of

	Percent
Soybean.................	60
Rice....................	20
Wheat...................	20

He is also trying

Soybean.................	40
Peanuts.................	20
Rice....................	20
Wheat...................	20

The results of studies with these products are not yet available.

American Multi-Purpose food has been made in a variety of formulas based on soybean meal. The results of controlled experiments with these products are not yet available.

There would seem to be no reason why an excellent product could not be developed, based primarily on soybean meal. There are undoubtedly a number of commercial products that have been developed and about which information is not yet available to me. Such products would necessarily have to be based on combinations of the various sources mentioned in this paper. Soybeans appear to offer one of the most attractive possibilities for making a suitable food mixture of high protein value at low cost. Mixtures of various other products such as corn and peanut flour with fish flour, meat powder, fish flour, dry skim milk, and the use of a variety of legumes would appear to offer the most attractive possibilities.

In conclusion, we have at hand the knowledge and the resources to improve the health of millions of people in the world today through improving their protein food supply within their own resources. I do not see any practical problem in the world's protein supply that

cannot be solved by education, research, and by good planning. There is one final point which I feel I must set forth although it may not be a popular one at this time. I can see no long-range advantage either to us or to the people concerned in trying to meet the world's shortage in protein foods for man by supplying foods from the United States. The people who are suffering most severely from protein malnutrition are in lowest economic groups in the most underdeveloped countries. There is very little hope in the foreseeable future that they will have enough money to buy imported products. The solution seems to me to be to improve their protein supply within their own resources with United States technical assistance, make them stronger and healthier so that they can become more productive, and thus raise their economic level so that we can do business together to mutual advantage.

Discussion: A question was asked on protein content of copra. It is about 6.6 percent; however, there is no published information on the biological value of copra protein. There are also commercial problems in handling copra.

IMPLEMENTATION OF THE WHO/FAO/UNICEF PROTEIN-RICH FOODS PROGRAM

Donald R. Sabin

Coordinator, Food Conservation, United Nations Children's Fund (UNICEF)

In November 1959, representatives from 78 countries in the General Assembly of the United Nations adopted unanimously a "Declaration of the Rights of the Child." This contained 10 principles. Principle No. 4 reads:

> "The child shall enjoy the benefits of social security. He shall be entitled to grow and develop in health; to this end special care and protection shall be provided both to him and to his mother, including adequate pre-natal and post-natal care. The child shall have the right to adequate nutrition, housing, recreation and medical services."

The same General Assembly stated: "...the aid provided through the Fund (UNICEF) constitutes a practical way of international cooperation to help countries carry out the aims proclaimed in the Declaration of the Rights of the Child."

I would like to stress that part of the statement which says "the child shall have the right to adequate nutrition." Dr. Sebrell has already described to you the world aspects of protein malnutrition, a world in which malnutrition, undernutrition, and starvation, even today, is the fate of half the world's children. UNICEF, with the advice and assistance of the United Nations World Health Organization and the Food and Agriculture Organization, is dedicated to helping governments improve the nutrition, health, and general welfare of their children. The needs are tremendous, and the United Nations agencies have the unique opportunity and responsibility of trying to improve the nutritional status of children in many countries. We give what direct assistance we can--but any such assistance is small in relation to the size of the task ahead. The greatest contribution of the United Nations agencies lies in the stimulus or encouragement that they can give to others within the country--be they governmental agencies, private companies, cooperatives or other associations.

While the Declaration of the Rights of the Child was approved only 2 years ago, the problem of assistance to children has been a major concern of the United Nations agencies since they were established in the late 1940's. UNICEF's first assistance in the field of practical applied nutrition was in 1947, the first full year of its operation as an emergency agency, when it sent foodstuffs to needy children in war-devastated countries, primarily in Europe. The

principal food item used on the recommendation of our advisors was skim milk powder. Since then, we have shipped to roughly 100 countries and territories about 500,000 metric tons of skim milk powder, and our present shipments are made at the rate of 120 million pounds per year.

In the early days, in addition to the health services provided, this milk distribution program was the backbone of UNICEF's assistance, and over the years it has proved to be a very important part of the Fund's contribution to feeding mothers and children. Besides the nutritional value of the milk itself, it has stimulated governments to think about and improve their own plans for better nutrition. Most of the milk powder, particularly in recent years, has been given to UNICEF by the United States Government, with UNICEF paying the ocean freight and the recipient countries paying the local distribution costs.

When normal supplies of skim milk powder were interrupted 2 years ago because of a brief disappearance of surplus milk in the United States, it caused grave consternation in many recipient countries and stressed the need for greater emphasis on using other kinds of locally produced foods rich in protein of good quality upon which to base child feeding programs.

As early as 1948, the UNICEF Executive Board decided to put a small amount of money into helping some of the European countries rebuild their milk plants. This was done in order that the feeding programs which had been started by UNRRA and continued by UNICEF could permanently bolster child nutrition in the countries in Europe where the milk industry had been damaged and disrupted by the war. The program proved so successful that it was extended to other parts of the world, and in the past 14 years UNICEF has allocated approximately $20 million for milk conservation programs. Equipment and other assistance has been authorized for 194 plants or dairies in 33 countries; the amount of such aid of course varies--from the supplying of single pasteurizing units to imported equipment for complete dairies. On the average, the governments have invested at least four to five times as much as UNICEF, making the total investment in new plants and related programs well over $100 million. FAO and, to a lesser extent WHO have contributed technical help to the projects. Milk being a known and accepted food for infants and children, these plants generally have proved to be most successful and appreciated.

In spite of the emphasis on milk production, processing, and distribution it has long been recognized by the United Nations agencies that in many countries dependence upon milk is not the solution, or certainly not the only solution to the nutrition problems of children. For climatic and other reasons, it is not possible in many of the developing countries to produce enough milk to meet the needs of their expanding populations; so other

sources of protein must be found to meet the ever-increasing need for protein-rich foods. In our search, we have examined three additional sources of high-protein or protective foods:

1. The promotion of village, community and school gardens (including the raising of poultry, rabbits, and fish)
2. Fish flour
3. Oilseeds

Concerning the first source, the local production of protective foods is developing quite well in many countries.

As to the second approach, some encouraging progress has been made in the development of fish flour for human use. It shows promise as a low-cost high-protein supplement to local diets. I will not go into details on fish flour in this meeting, since that is the subject of another conference to start next week in Washington, D. C.

Oilseeds and their products we have studied include:

1. Soybeans and soy flour
2. Cottonseed flour
3. Peanut flour
4. Sesame flour
5. Coconut
6. Sunflower seed flour

We have also given some attention to leaf proteins, especially manioc or cassava. The immediate use of the leaf proteins on a large scale does not seem likely.

Our first effort in assisting a country with development of soy products was at Jogjakarta, Indonesia, with a soybean processing plant. This plant makes an aqueous extract of the soybean and sesame which is heat-treated, spray-dried, and supplemented with sugar and certain other elements; it has been given the trade name of Saridele. The product is proving to be very acceptable in Indonesia, not only as a food for young children but especially as a flavored drink for the populace generally. Two types of Saridele are being marketed: One used in the child feeding programs and the other, having a higher sugar content, being sold as a popular beverage.

Even though the plant is working to capacity and plans have already been made to double its output, the relatively high price of the product for child feeding is of concern to us. While it is only about half the price of imported whole milk powder of comparable composition, the quantity required to feed a child in one day, if this were the sole food (which it probably would and should not be), would cost approximately one-third the average daily wage of a manual worker. This illustrates the problem which confronts governments and the international agencies trying to find protein-rich foods of good nutritional value that can be purchased by the low-income groups.

In an effort to find ways of reducing costs and of standardizing the quality of processed soy products, UNICEF is providing some funds for research being done by Dr. David Hand's group at Cornell University. It has also contracted with the A. D. Little Company to develop acceptable uses of soy grit products without further expensive processing. Two small grants have been made to soybean investigators in Japan. The Northern Utilization Research and Development Division of the USDA is generous in advising us on better ways of preparing soybeans for human use.

We are greatly pleased with the interest being manifested by the soybean industry in developing and expanding the use of soybean products as human foods. The industry's strong support for this Conference is most gratifying.

We see in soybeans one of the cheapest sources of high-quality vegetable protein available in those areas where soybeans can be grown efficiently. Since they also lend themselves well to shipping, they can easily supplement production in many areas where production is insufficient to meet local requirements. However, UNICEF's long-term interest is in the processing of domestically produced soybeans in countries where they are needed to improve the nutritional status of the population.

Cottonseed flour, which was developed in this country about 20 years ago and has found perhaps its greatest use in doughnut manufacture, is now proving to be a good-quality protein to use in child feeding programs. The product called INCAPARINA, developed by INCAP in Guatemala under the guidance of Dr. Nevin Scrimshaw, contains about 38 percent cottonseed flour and has demonstrated that it can be used to prevent and cure kwashiorkor, a protein-deficiency disease which is now recognized as common to many of the tropical areas of the world. In a number of countries cottonseed is currently undergoing tests as a protein supplement to local diets, and we are optimistic that its use will eventually add materially to the quantity of good-quality protein available for human nutrition. A meeting similar to this one was held in New Orleans in November 1960 on cottonseed. It was sponsored by the USDA, Southern Utilization Research and Development Division, in collaboration with the National Cottonseed Products Association and UNICEF.

Peanut flour is beginning to attract considerable attention as a readily acceptable protein supplement to local diets. It has been reported that in India, the world's leading producer of peanuts, over 75 percent of the press cake is used as fertilizer. It is mainly extracted by crude machines that leave a residual oil content of 10 to 12 percent in the cake. However, it becomes rancid quickly and cannot be stored long enough to be used even for livestock feed. UNICEF is providing equipment to two commercial plants in India to help upgrade their present cake and hopes that an acceptable edible product can be made on a commercial basis.

Testing has been done by collaborators, including those who receive aid, under a grant from the Rockefeller Foundation, from the Committee on Protein Malnutrition under the chairmanship of Dr. Sebrell. This testing has shown that peanut flour as a source of protein alone has its limitations, but when supplemented with relatively small amounts of certain other protein-rich foods such as skim milk the mixture is a very satisfactory protein product. Two British-owned companies are marketing such mixtures in Nigeria, one supplementing the peanut flour with skim milk powder and the other with casein. It is interesting to note that the two major peanut-producing countries are in Asia and Africa--ironically, areas where protein malnutrition is severe. Much of the oil and most of the better-quality cakes are exported. Only a small fraction of the protein-bearing cake is used for human consumption or even for cattle feed in the countries in which peanuts are grown.

A relatively modest amount of work has been done with sesame flour; until we tried solvent extraction it was not possible to produce a satisfactory and economical product. The essential amino acid pattern of sesame flour, being high in both sulphur-amino acids and tryptophan, makes it, theoretically at least, the most suitable of the protein-rich foods with which to supplement the traditional diets consumed in developing countries.

Sesame seed is usually expensive compared with other oilseeds, and we are still trying to determine both its value as a human food and the economy of its preparation. Sesame is being used to some extent in Indonesia in the Saridele which I mentioned earlier; its significance in the formulation of the final product is not yet fully determined except that it seems to add a pleasing flavor and possibly a certain amount of stability to the final product. Costs and nutritive value are still under study.

As for coconuts, one is always dismayed at the large amount of protein that is lost under the present method of handling them. Since coconuts are processed primarily for the oil, and the meal is used as livestock feed and as fertilizer, it means that here is a potential source of protein which might be considered as partially wasted. It is estimated that there are some 3 million metric tons of copra produced annually.

The average protein content of copra is only 6 to 9 percent. Still this means a potential supply of over 200,000 metric tons of protein which, with better techniques, might be converted into human food. To date we have been unable to locate or develop a satisfactory and economical method for recovering this protein for human use.

Sunflower seed flour is of relatively minor importance except in a few countries of South America and Eastern Europe. Very little work has been done on this product, but some very interesting

results have come to our attention indicating a relatively high quality of sunflower seed protein. A solvent extraction process followed by sieving appears to be a favorable method of processing.

An important element in the development work has not yet been mentioned, namely, the role of the WHO/FAO/UNICEF Protein Advisory Group (PAG). It was established in late 1955 by the Director General of WHO with Dr. William J. Darby as chairman to advise on the suitability, safety, and nutritional value of the various foods which we were trying to develop for infants and young children. The PAG was originally responsible only to WHO, but it has recently been reorganized as a tripartite group advising all three agencies. Its present chairman is Dr. Paul György. The group consists of internationally known nutrition scientists who donate their services to the work. The efforts of this dedicated group have resulted in a carefully planned approach to the use of new food products as to their nutritive value and safety.

In the foregoing I have stressed the importance of developing nutritious and acceptable foods at the lowest possible cost. I would illustrate the need to stress cost by the following figures Half of the underdeveloped countries--and two-thirds of the people in these countries--have an average per capita income of less than $100 per year. Therefore it is imperative that any new foods or food supplements be closely related to the prevailing price of the local staple foods, or the people simply cannot afford to buy them.

In conclusion, millions of people, particularly children, are inadequately fed. The world is awakening to the need and is demanding prompt action--faster action than we have so far been able to give. Modern techniques need to be applied vigorously to find practical answers to pressing food needs that are expected to continue to mount rapidly.

The United Nations agencies are diligently searching for solutions. While finding solutions to the technical problems is difficult enough, we believe some of the more important answers have already been found. Applying and adapting these solutions to local situations is even more challenging. FAO and ourselves are giving increasing attention to this phase of the problem. The training of local people is recognized as basic to progress and improvement and is at the heart of the efforts of many of the United Nations' programs of assistance.

This meeting is indicative of the growing awareness of the world's food problems with special emphasis on the role soybeans may play in solving them. It recognizes the need for intensifying our common efforts to make better use of our existing and potential food resources. This is a positive note in a world plagued with conflict and strife.

FOOD FOR PEACE: PLANS AND OBJECTIVES

Nelson J. Post

Assistant to the Director of Food for Peace

The subject of your Conference and the agenda are timely and I am sure will produce much useful information.

To say it is a pleasure for me to be here would be recorded as the understatement of the Conference. I am absolutely overwhelmed when I realize the knowledge and resources you represent.

I am, therefore, even more appreciative of this opportunity to be here and to talk with you about Food for Peace.

In essence the Food for Peace concept is a cooperative effort among governments and private agencies and groups to utilize our agricultural abundance prudently and skillfully as an instrument in the on-going world struggle for peace.

The Program can be no more aptly described than by quoting the statement made by President Kennedy 4 days after his inauguration. In a memorandum to the Heads of Government Agencies in which he outlined the responsibilities he was assigning George McGovern as a Special Assistant to the President and Director of the Food for Peace Program, the President said: "American agricultural abundance offers a great opportunity for the United States to promote the interests of peace in a significant way and to play an important role in helping to provide a more adequate diet for peoples all around the world. We must make the most vigorous and constructive use possible of this opportunity. We must narrow the gap between abundance here at home and near starvation abroad. Humanity and prudence, alike, counsel a major effort on our part."

This prudent use of our agricultural abundance is where you, as people knowledgeable in the fields of production, distribution, and nutrition are so vital to the Food for Peace Program.

On the question of nutrition, the World Food Deficit Study, prepared by an interagency committee chaired by USDA, shows the greatest nutritional shortages to be in the protein area. Extreme shortages of animal protein exist in Western Asia, Africa, the Far East, and large parts of Latin America. The harsh fact is that millions of the world's population face hunger. You know, of course, that this amounts to a staggering total of human misery. Hunger's full toll in human deaths or its lesser toll in loss of physical and mental vigor do not spell merely personal tragedy. They also seriously diminish the common pool of human activity, imagination, and knowledge--an immeasurable loss when it is remembered there is no peace, no real freedom, in the bonds of hunger.

Even in countries where the average diet is above the nutritional standard, large pockets of the population are malnourished and these are not necessarily in the interior, many are in the shadows of cosmopolitan cities.

The challenge in this situation is clear. You have shown a sensitivity to it and a willingness to help meet it. The American farmer has proved his ability to make a material contribution. The job then is to marshall all the resources--public and private--and get on with the job.

Progress is being made. Let me give you a capsule summary of developments in recent months.

1. Congressional authorization to use an additional $2 billion worth of agricultural commodities during calendar year 1961 had made possible accelerated sales of these commodities for foreign currencies. Total authorization this year is $3.5 billions.

2. A meeting of voluntary relief agency representatives held at the White House in April provided a forum for discussion of their food distribution problems and proposals for increasing their effectiveness in the expanded Food for Peace Program. At this meeting, Secretary of Agriculture Freeman and Mr. McGovern announced that additional quantities of nonfat dried milk and vegetable oils were to be made available to the agencies for use in their overseas activities. These programs benefit approximately 60 million people in over 90 countries.

3. The Food for Peace Missions to Latin America in February and early March of this year generated increased use of food in child and maternal feeding programs and in economic development projects.

   An agreement signed in May with the Government of Peru providing a school lunch program for 30,000 Peruvian school children is highly significant. It represents the first government-to-government school feeding program to be signed with a Latin American nation.

4. Over the past months it has become increasingly evident that the use of food in economic development projects offers one of the greatest potential opportunities in the Food for Peace Program. Dramatic progress has been made under legislative authority permitting the use of food as partial wage payments in underdeveloped areas. Until this year the extent of the food for wages program was a pilot project in Tunisia, but it is now operating in 7 countries and negotiations are underway with 26 additional countries. Under this authority we are

moving forward with a program to convert our accumulated feed grains to protein foods through the production of poultry and eggs. We are currently appraising the feasibility of doing this through producer cooperative mechanism.

5. Greater emphasis was given to the multilateral attack on world hunger in April when the Food for Peace Director initiated, at an FAO Conference in Rome, the establishment of a commodity "fund" of $100 million for use by the Food and Agriculture Organization of the United Nations.

6. Arrangements were made with representatives of the Indian Government and CARE to supply U. S. agricultural commodities for a school-feeding program in Madras, India. The proposed program will provide food for half a million school children and represents one of the largest child-feeding programs in the Far East.

7. A national Food for Peace Council, appointed in May, includes over 100 representatives of agriculture, labor, industry, commerce, and civic groups. The first conference held in June provided the Council members an opportunity to secure background information on the Program and to meet public officials concerned with its operation.

   A Freedom from Hunger Committee selected from the Council membership is proceeding with the establishment of the Freedom from Hunger Foundation. The Foundation will enlist support from the U. S. private sector for the Food and Agriculture Organization campaign.

8. A program to increase the use of wheat in the Food for Peace Program has been authorized. The distribution of 60 million pounds of a wheat product, bulgor, by the voluntary relief agencies is an effort to increase commodity availability and protein content.

9. A task force representing the Food for Peace Office, USDA, and the AID agency is determining the feasibility of increasing the nutritional content of the program. By converting accumulated stocks of cereal grains to products with higher protein content, we hope to meet the need for protein foods and more effectively manage our large stocks of cereal grain.

   A short time ago representatives of the soybean industry met in Mr. McGovern's office with representatives of the United States Department of Agriculture and the International Cooperation Administration to discuss various soybean products and their possible use in the Food for Peace Program. The continuing review of these proposals is being carried on by a committee chaired by Assistant Secretary of Agriculture, John Duncan.

One of the most dramatic uses of food under Public Law 480 has been in the form of wage supplements for workers engaged in fundamental labor projects on the so-called "infra-structure" of underdeveloped communities. Thus, in Tunisia, some 70 million man-days of work have been put in on reforestation, irrigation, housing, sanitation, and like efforts, with American wheat providing from one-third to a half of the total wage. This is the type of program Morocco has just signed. Korea and Afghanistan have it. It should work in many parts of Latin America and, indeed, most areas where people are both jobless and undernourished. Here, food can provide directly the necessary stimulus and leverage to raise economic and social conditions without prior conversion into local currency--a step which often bypasses the neediest. Under the new leadership of the foreign aid program, it is anticipated that even greater strides will be made in the use of agricultural commodities as a resource in economic development efforts of developing countries.

Now, let's look at Food for Peace from another angle. Our farm and agricultural trade groups actively engaged in promoting commercial exports obviously have a very real interest in Food for Peace activities carried on under Government sponsorship. The most obvious interest, of course, stems from immediate material benefits. The approximately 30 percent of U. S. agricultural exports which is now moving under the various Food for Peace programs unquestionably strengthens farm income and farmer purchasing power.

A less obvious but equally important interest arises from the fact that while the countries participating in the Food for Peace Program lack hard money purchasing ability now, we hope they will become dollar customers as their economies improve. Examples of countries which are now good dollar customers for our agricultural commodities, but which were once recipients of foreign aid or Public Law 480 commodities, are Italy, Japan, Portugal, England, Austria, France, Germany, and Spain.

Nor is the opportunity for providing services which can pay good dividends in the future limited solely to commercial channels. Under appropriate circumstances, U. S. trade groups can be of assistance in nutritional education, school lunch, and other feeding programs which shape dietary habits in the direction of foodstuffs the U. S. produces in abundance, and in which the recipient country cannot efficiently become self-sufficient.

There are many U. S. trade and commodity groups doing excellent work abroad, including the types of activities I have mentioned, both in hard money markets and in those countries which are participating as recipients in the Food for Peace Program. I know that this work has contributed greatly to the present high level of agricultural exports and giving additional meaning to Food for Peace.

In our efforts to expand the sound and constructive use of agricultural abundance, it is clearly necessary that there be understanding between the agencies of government concerned with these efforts and all segments of the nongovernmental community. To the extent that we can maximize communication between public and private agencies, we are doing so. Further, it is our confirmed belief that an effective marshalling of public and private resources in the field of food distribution is essential.

The American agricultural production plant has built a capital asset of national proportions unknown in any other country of the world. An asset that certainly must be the envy of the USSR. Our abundance of food has placed us far ahead of the Soviet-Sino Bloc in the area of food production. On a very practical point we are in competion--yes even in a rivalry--with the Communist world. It is axiomatic that in any form of competition or rivalry one is well counseled to emphasize and utilize to the utmost that talent or ability where he has his greatest strength. Certainly in the field of food production, the strength of the United States is second to none.

In the newly developing areas of the world where the subtle, long-range struggle between East and West for the hearts and minds of men is being waged, the full force and effort of this asset can be brought to bear. This is a struggle with real meaning. In these areas live about one-third of the world's population. By and large these peoples are uncommitted in this struggle between East and West. The challenge is here. The opportunity is now.

Early in these remarks I said I was overwhelmed by the knowledge represented at this Conference. This knowledge, marshalled as it is in this Conference, assures us that the challenge can be met and dealt with successfully.

Your counsel as to how best soybean products can contribute to improved nutrition in the decade of the 60's is needed and is sought.

What you do here can provide a tremendous backstopping to the vigorous efforts all of us must put forth.

The concept of Food for Peace can be the device through which we focus sharply on the problems with which we must contend. Through it your counsel can be brought to bear in the vigorous prosecution of the job facing us.

Soybeans will loom large in this effort. Actions already taken underscore this.

For Food for Peace this is a propitious time. Here in Peoria we have the national and international leaders in the field of nutrition. We have represented the conviction of this Administration that the use of our agricultural abundance is prudent. We have

represented the industrial know-how of processing and marketing. And as a backdrop for all of this, we have the expectation of a billion-bushel soybean crop in the foreseeable future.

From this combination of resources and interest who would hesitate to predict an exciting role for soybean products for human foods in the 1960's?

Discussion: Dr. Sebrell commented that in regard to use of feed grains for poultry, Ralston-Purina in Guatemala has done more for nutrition in Central America than has been accomplished by special foods. Pushing broilers and eggs through farm coops has reduced the price of poultry from $1 to 30 cents per pound.

Dr. Hand commented that handouts do no permanent good. Reforestation and other work reaps lasting good. Payment of wages partially by food has been particularly good. In Formosa farmer coops were strengthened by handling distribution of soybean meal. Lebanon imports wheat--it can just as well be American wheat.

The question was asked as to why the chicken program has moved well while Incaparina has not. Several things contribute to this: (a) Palatability, (b) chicken consumers are not the same as the incaparina consumers who, for the most part, have incomes of less than $300 per year, and (c) also the chicken program was initiated by ICA 15 or more years ago while Incaparina has been at a pilot level only within the past 18 months.

Session II

WORLD MARKETING OF SOYBEANS AND SOYBEAN PRODUCTS

Mr. Robert G. Houghtlin, Presiding
President, National Soybean Processors Association

MARKET DEVELOPMENT ON U. S. SOYBEANS AND SOYBEAN PRODUCTS

Geo. M. Strayer

Executive Vice President and Secretary-Treasurer,
American Soybean Association

Among producers of major agricultural products in the U. S. producers of soybeans are in a unique position. Despite increases in production which are out of all proportion to normal expectations the markets for the crop have grown in approximate proportion to the production and there have never yet been surpluses of a proportion to justify classing the crop in the same surplus category with wheat, corn, cotton, tobacco, and other major U. S. crops.

First, let's take a look at what has happened in soybean production. From Table 1 you will note that from a production too small for USDA to gather figures before 1924 the production zoomed to 78 million bushels in 1940. During the war years we more than doubled soybean production, and many people at that point considered soybeans to be a war baby and insisted that following the close of the war we would never again see soybean production as high as 100 million bushels per year. The figures in the table speak for themselves--with an official crop forecast by USDA on September 1, 1961, of 725 million bushels, and with general agreement in the trade now that the crop will exceed 700 million with some estimates as high as 738.5 million bushels.

Soybeans have continued to grow in favor with the U. S. farmer for a number of reasons. New and improved varieties bring higher yields and greater net returns. Adaptability of soybeans to mechanical production methods, requiring a minimum of hand labor, is another factor. Restrictions of various types on acreages which could be planted to other crops have most certainly contributed. An awareness on the part of producers of a growing and enlarging market has also contributed to the expansion in soybean acreage, for it has been known by every producer that a buyer was ready to purchase his crop whenever he was ready to sell, and at a price enabling him to pay his operational costs and show some profits.

The markets for soybeans have grown because demand for products has grown, both at home and abroad. Those product markets have expanded because soybeans happen to produce in quantity both protein and oil--two of the most scarce commodities in the world food economy. In most areas of the world carbohydrates in one form or another are relatively plentiful--in wheat, corn, rice, barley, sorghums and milos, millets, and a host of cereal crops. The scarcities are in the form of protein and edible oils. Soybeans contain about 20 percent edible oil and 40 to 42 percent protein as

Table 1.--United States soybean production and usage by crop years*

(October 1 through September 30)

Crop year	Production	Domestic crush	Production of oil	Production of meal	Exports
	Mil. bu.	Mil. bu.	Mil. lb.	1,000 tons	Mil. bu.
1924-25	4.9			25.9	
1940-41	78.0	64.1	564	1,543	0.3
1945-46	193.2	159.5	1,415	3,837	2.9
1950-51	299.2	252.0	2,454	5,897	27.8
1955-56	373.5	283.1	3,143	6,546	67.5
1956-57	449.4	315.9	3,431	7,510	85.4
1957-58	483.7	353.8	3,800	8,284	85.5
1958-59	579.7	401.2	4,251	9,490	110.1
1959-60	533.2	393.2	4,329	9,127	141.1
1960-61	558.8	405.0 (est.)	4,400 (est.)	9,400 (est.)	141.0 (est.)
1961-62	725.0 (est.)				

* 1961 Edition Soybean Blue Book.

they come from the farms of America. In addition, that protein which is the subject of this conference is the most nearly balanced in the amino acids of the vegetable proteins available in quantity in the world today.

Soy protein is the base upon which the huge livestock industry we have in the U. S. today was built. Not until we had soy protein, properly prepared, in quantity and at a reasonable price did we have the broiler industries, the egg industries, and the swine industries as we have them today. All are built on a foundation of soy protein.

But even in an economy as flourishing as ours in the United States there are people who are not receiving adequate supplies of protein today. And a large proportion of the people of the world can neither afford nor obtain animal proteins. From no choice of their own they must obtain their proteins from vegetable sources. Among those sources is the one we are considering today--soy protein.

Now the continually expanding markets for soybeans and soybean products have not come through happenstance or chance. Tremendous amounts of research work by agricultural colleges and research stations, as well as by feeders and feed manufacturers, went into the

development of techniques of proper soybean meal preparation for livestock feeding, and into the feeding experiments necessary to determine proper levels of usage. When those determinations had been made, and the economies of usage of soybean meal definitely established, a vast number of feed dealers, salesmen, and feed manufacturers representatives applied themselves to the sales job to be done. The results are shown in the figures on soybean meal production--for those figures, except for some small quantities in exports, also represent soybean meal usage in tons. Over 74 percent of the total tonnage of protein meal fed to livestock in the United States last year was soybean oil meal.

A similar story might be told on usage and sales of soybean oil. Today soybean oil constitutes our major source of edible oil in the United States, and our major export of vegetable oil into markets of the world.

As the production of soybeans in the United States continued to grow during the postwar years it became evident that we could produce in this country more soybeans than we could consume advantageously. At the same time it began to appear that other countries in the world might adopt U. S. soybeans into their economies, and that we had something which might offer potential export markets, either in the form of beans or as oil, meal, flour, or other end products.

In 1949, I made my first trip overseas to explore market possibilities. J. L. Cartter of the U. S. Regional Laboratory at Urbana and I went into several of the northern European countries to determine what the soybean production potentials might be--and what our market possibilities looked like. In 1952, I went back again and at that time made a careful study of potentials in 10 European countries. In 1954, I went back as a member of a Foreign Trade Team sent by USDA to determine why we were losing our foreign markets for U. S. farm products.

During 1954, Public Law 480 was passed by Congress, providing for the sale of U. S. surplus farm commodities for foreign currencies, with a portion of the proceeds to be made available to trade groups to enlarge and expand the markets for U. S. agricultural commodities. Soybeans were not in surplus, and were not made available for sale for foreign currencies. However, this did not preclude use of money accumulated from the sale of wheat, cotton, tobacco, butter, lard, and other commodities from being used to sell soybeand and/or soybean products.

By the time P.L. 480 became operative a sizable group of people in the soybean industry had become aware of overseas market potentials for our products. We knew that potential markets existed, and that it was our responsibility to go after them. We decided to do just that.

By 1955 Japan had become our largest single customer for U. S. soybeans. We were hearing complaints on quality, especially on foreign material content. Our varieties were strange to them, our methods of mechanical handling not understood and our grades and grading standards were confusing. Japan appeared to be an even bigger potential customer if we could help them solve some of the problems of using our product.

Recognizing the situation, the Agricultural Attaché in Tokyo requested that the American Soybean Association, representing the soybean producers, send someone to Japan to work with the trade in that country. The Fats and Oils Division of Foreign Agricultural Service concurred, and it was my personal pleasure to spend 6-1/2 weeks in Japan in late 1955. Out of that visit came the organization of a joint operational agency, called the Japanese-American Soybean Institute. Mr. Shizuka Hayashi was employed as managing director in early 1956, and since he will appear on this program later I will not describe in detail that organization or its operations.

Since early 1956 the American Soybean Association, in conjunction with Foreign Agricultural Service and five Japanese trade groups has been operating this market development project on soybeans in Japan. The major activities have been in the field of education of the housewife on the place of protein and edible oil in the diet of the members of her family. Soybeans have been grown and used in that country for centuries, but the intake of both protein and oil were far below minimum standards, especially in the rural areas. Animal products were not available, and would not become available in quantity in the foreseeable future. Increased intake of protein and oil had to come from vegetable sources. The Japanese consumer was familiar with miso, tofu, shoyu, natto, kinako, and a long list of soybean protein products, and also with soybean oil for a cooking and salad oil.

The services of trade organizations, governmental and quasi-governmental agencies, prefectural governments, and many other groups were enlisted. Throughout Japan the story of soy products and their value to health were repeated in a myriad of ways. Demonstrations, movies, training schools, extension workers, nutritionists, mobile demonstration buses, and a host of other avenues of approach have been used. Millions of housewives have been told the story in many ways and in many places.

Results are the only true measurement of success or failure in an endeavor of this type. In the 1955 crop year U. S. exports of soybeans to Japan were 20,402,000 bushels. In the 1959 crop year, the last on which export figures are available, Japan's imports of U. S. soybeans had increased to 40.8 million bushels--every bushel sold for dollars. And this increase came under very strict governmental currency controls which greatly limited soybean imports into

Japan. At least partially as a result of the buildup of demand for U. S. soybeans by foods manufacturers in Japan, created by demand for soybean oil and soy protein products, the Japanese government on July 1, 1961, for the first time since World War II, placed soybeans on the Automatic Allocation basis. It is our expectation that imports of U. S. soybeans into Japan will increase materially above present levels as a result of this action. In fact, at our recent American Soybean Association convention Mr. Hayashi predicted a virtual doubling of Japanese imports of U. S. soybeans in the next decade.

Our experiences in Japan demonstrated to us early in the game that soybean markets could be expanded by expanding consumption of products. Our Japanese experience suggested that in many areas of the world the job was an industry-wide job, rather than a job for producers alone. We visualized that soybean handlers, soybean processors, exporters of soybeans, exporters of soybean oil and exporters of soybean meal all had a stake in expanding our overseas markets. In 1956, I made an intensive study of the potential markets for U. S. soybean products in 10 European countries. As a result of this study a series of committee sessions and industry conferences were held, resulting in the formation of an industry-wide nonprofit promotional organization, the Soybean Council of America. Financed by a voluntary check-off on the basis of bushelage or tonnage of soybeans crushed, handled or exported, the Soybean Council of America, Inc. now has active promotional programs launched in over 20 countries, and has 15 overseas offices scattered from India to Denmark to Peru, where staff members are stationed to do educational and promotional work designed to increase the markets for U. S. soybean products and soybeans. We recognize that in those countries where processing facilities are located they will buy soybeans and produce their own end products. We also know that many countries have need for oil and not for protein, and that other countries have adequate supplies of oil but are badly in need of protein supplies. As representatives of the U. S. soybean industry we consider it our function to sell the products the buyer wants in the form in which he desires them.

Cooperation among producers and processors of soybeans in the financing of the Soybean Council program has been gratifying. The dollar expenses of the promotional programs are borne by the U. S. soybean industry, and through the cooperatives program with Foreign Agricultural Service of the U. S. Department of Agriculture, as will be explained by Mr. Hougen, your next speaker, foreign currency funds are made available in certain countries for payment of market promotional and development expenses within those countries.

The job is different in each country and in each area of the world. Procedures, local agencies, and organizations with which work can be carried on, customs, religious beliefs and taboos, and a host of

other factors influence the exact procedures to be followed. Some countries are familiar with soybean products. Others are totally unfamiliar with them. Some countries have import handling facilities, others have none. Some peoples know what protein is and what it does, others have no such knowledge. Some governments encourage higher nutritional levels, others tend to discourage them. Some countries have local protein supplies which are not being used to the best advantage of their people. Other countries must rely on protein from outside sources. Some countries have or are developing the mechanisms of distribution of information, others have no such educational facilities. The mechanisms of development of markets must be made to fit the existent facilities within the country concerned, regardless of the stage of development.

To properly plan and execute market development programs, then, requires a knowledge of the customs, educational levels, educational facilities, basic interests, the languages and the economic levels and stratification within the nations concerned. Recognizing these things, it has appeared advisable to employ local personnel, fully acquainted with the conditions within the country and the language or languages of the people with whom the work will be done. The American Soybean Association has done just that, and so has the Soybean Council. Each director of a country project is a native of the country in which he works. He knows the people, their customs, and their language.

From the U. S. side we then supply the technical know-how which appears necessary. We supply technical men from the U. S. to work with the country directors. We hold training schools for the directors and other employees, training them in methods and procedures. We encourage sponsorship of seminars and symposiums to which we send highly skilled and technical men from the U. S. to fully acquaint people within the industry of the country concerned with our products. The Soybean Council retains Dr. J. W. Hayward to direct the nutritional activities of our programming, and since he also appears on this program, as well as being one of the men who planned the program, I need not go into detail on his activities. As a technical man on soybean oil the Council retains Mr. Edward M. James to handle the technical assignments in soybean oil, storage, handling, refining, and usage. These two men, assisted by many others recruited from within our industry for specific assignments, have visited many of the countries of the world to assist in U. S. soybean product usage.

Up to this time most of the work in soy protein utilization has been in the field of livestock feeding. However, in Japan there has been much emphasis on soy protein for direct human consumption, and in Israel work is now being done in the possible adaptation of oriental-type soy foods to usage in other areas. Exhibits have been sponsored at Trade Fairs and exhibitions in many countries to give potential consumers an insight into possible uses of soy protein in their

country. Millions of people have been exposed to soy protein and oil through these exhibits. We consider this to be a very logical and worthwhile means of introducing soy products to people who otherwise would know nothing about them. However, we very well recognize that unless properly followed with sales and promotional work a fair exhibit is of little value to market development. Acquainting people with a product not available to them does not result in sales. It only results in frustrations.

These first few years of operation of the market development projects by both the American Soybean Association and the Soybean Council of America have largely been years of exploration and development of staffs and techniques. The active promotion of markets for American agricultural commodities is something new, and even after 6 years of overseas promotional experience we still have much to learn. We do now have in the soybean industry the nucleus of what we hope will prove to be the most active commodity promotional group in American agriculture. In the United States and in foreign offices established by the two organizations some 75 people are now working full time to merchandise the products of U. S. soybeans. They are of all creeds and races, of all ages, and backgrounds. But they have one thing in common--they are dedicated to the future of the products of American soybeans.

This staff is new. Some of them have been working only a few months. Additional personnel will be added as needed to expand the programs into new areas and new countries, as well as expanding the activities within the countries where programs are now underway. Because these staffs are new you have not yet heard great results from many of them. The groundwork is now laid. With a staff built, we will see in the 1961 crop year starting October 1 just how much of the 700 million-bushel crop we can place into channels of consumption here in the U. S. and in countries where work is progressing. This year should provide us with a good test of the effectiveness of the machine which has been built to do soybean and soybean product market development.

I want to make it very clear that the people employed by the American Soybean Association and the Soybean Council do not carry order books. They sell ideas. They work with governmental agencies and representatives, with industry trade groups, and with individual companies and their personnel. They work with the buyers and potential buyers of soybeans or soybeans or soybean products. They do the educational work, the promotional work, the negotiations, the demonstrations, the contact work which creates demand and should result in sales of proteins and oils.

But before the market development programs can be really effective sales of products must result. This means that the firms comprising the soybean industry of the United States must provide the sales force to turn desire for products into sales contracts. This

means that processors, oil refiners, flour and protein manufacturers, grain exporters, lecithin manufacturers and all other firms which are a part of our industry must have men on the spot at the right time with competitive quotations. This must be followed by the ability to make deliveries of a quality product at the time and place desired by the buyer.

It also means that strict observance of grades and standards of quality must be observed by U. S. firms entering these markets, and in many cases it means cooperative working arrangements with companies within the country of sale. It means servicing the accounts after sales are made in order to retain buyers as customers. It means all those things which a company would do within the United States to build and retain a market.

But it also means salesmen and servicemen who can speak Spanish, French, Italian, Arabic, German, Danish, Hebrew, Hindu, Urdu, and a host of other languages. It means personnel with the tolerance and the wealth of understanding which will permit them to place themselves in the position of their customer and understand his demands, his needs, and his desires.

It means elimination of those classic examples where an American seller takes advantage of a foreign buyer and because of language, trade customs or some other excuse makes delivery of poor quality or shoddy goods to a foreign buyer. It means the delivery of high-quality products to those who buy them and pay for them. It means regarding the export market as a permanent and desirable one, to be retained through a period of years, rather than a place to dump undesirable goods. It means the establishment of man-to-man contacts and the sense of trust and reliability which are so necessary in continued profitable relationships between buyer and seller. It means taking the knowledge and know-how of the American soybean industry to buyers in foreign countries in order to capitalize on the market development machine which has now been built.

With producers, handlers, processors, refiners, and exporters of soybeans and products cooperating in the market development activities, and with the proper followup on the part of sales forces representing the sellers, we have only scratched the surface on potential markets for soy products, including soy protein.

We came out of the war producing a crop of 180 million bushels of soybeans. We are now at the 700 million-bushel production level. In the next decade I expect to see the production of a <u>billion</u> bushels of soybeans per year in the United States. With our present knowledge of markets and the promotional organization which is being built we can find <u>dollar markets</u> for that amount of product. We have only seen the beginning, as shown in Tables 2 and 3. The results of the organization are yet to come. The world needs more soybeans. We can produce them profitably here in the U. S.--and we can and will market them at home and throughout the world.

Table 2.--United States soybean oil exports (1,000 lbs.)*

(October 1 through September 30)

1951-52	273,489
1952-53	94,565
1953-54	71,259
1954-55	50,203
1955-56	556,394
1956-57	807,262
1957-58	803,986
1958-59	930,439
1959-60	952,754

* 1961 Edition Soybean Blue Book.

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Table 3.--United States soybean meal exports (1,000 tons)*

(October 1 through September 30)

1950-51	181.1
1951-52	41.8
1952-53	46.8
1953-54	66.5
1954-55	271.7
1955-56	400.4
1956-57	443.2
1957-58	300.0
1958-59	512.2
1959-60	652.3

* 1961 Edition Soybean Blue Book.

Discussion: To Dr. Bean's question, "What will you do if your one billion bushel crop occurs in the next 5 years?" Mr. Strayer replied, "We will just have to work harder, faster, longer, and in more places to sell the crop. We have the marketing machine established and are ready to do the job."

ACTIVITIES OF THE FOREIGN AGRICULTURAL SERVICE IN DEVELOPING MARKETS FOR U. S. SOYBEANS AND SOYBEAN PRODUCTS

Volorus H. Hougen

Chief, Foreign Marketing Branch, Fats and Oils Division, Foreign Agricultural Service

An opportunity to discuss the overseas marketing activities of the Foreign Agricultural Service is always welcome. It also is a privilege to learn more about the new protein products being developed to enrich our own lives and the living standards of millions of people in other countries.

The marketing work of the Foreign Agricultural Service is aimed at finding new outlets abroad, not only for soybeans and soybean products, but also for many other commodities produced on American farms. The Service is in earnest about this work. A great deal of public and private money and effort are expended for this purpose.

Foreign market development activities have been undertaken in more than 50 countries in cooperation with over 40 trade and agricultural organizations. From the start of the program, almost $41 million of public funds have been made available to such groups. U. S. cooperating organizations have committed themselves and foreign industry to support the program by expenditures of not less than $17 million. The soybean industry of the United States, as represented by the American Soybean Association and the Soybean Council of America, has assumed responsibility for more than $4 million in Government funds and has committed themselves and their foreign associates to the expenditure of at least $2 million in private funds.

By our own inclinations and by legislative direction the market abroad that we survey and approach with the maximum of energy is the recognized dollar or hard money market. In considering this market there immediately comes to mind countries of West Germany, Canada, Japan, and several others of the greatest importance. In recent years, balance of payments, gold and dollar reserves and foreign exchange earnings have become household words more meaningful and important to all of us than ever before.

Many of you were at the recent American Soybean Association meeting in Indianapolis and heard Bob Tetro, the Administrator of our Service, Howard Roach of the Soybean Council, and others give the picture--and it was a good one--of marketing efforts in what we may call developed and developing countires. Measure the marketing effort by the record; more U. S. soybeans exported during July 1960-June 1961 than ever before in history. This was also true for soybean oil and for soybean meal. In terms of dollars, the record

export of soybeans and products contributed greatly to the total sum of $3.4 billion dollars exports of U. S. agricultural commodities in 1960-61. The total dollar sales to which I refer amount to about 70 percent of the total farm product shipped. So, as we said in Indianapolis, we would like to say again we are proud of the people who have labored with us in market development work, and we are most proud of what has been accomplished.

Outside of financial assistance, there is another area in which we in the Foreign Agricultural Service have worked. This is seeking trade liberalization. We have had cooperation from the trade in this effort too, and will welcome more. Some success has been achieved in lowering trade barriers. We shall continue to work for improvement in our market position around the world through all appropriate channels.

This work is backstopped in FAS by a continuing flow of information on production and trade elsewhere in the world. This information is passed on to the trade in the best manner possible. We believe any study made of the information put out by the U. S. relating to all aspects of world agricultural trade will clearly show U. S. reporting is superior by any standard. Here, too, we have called on the trade to work with us and supplement the information which pours in to the Department of Agriculture from its 56 attaché posts and from its marketing specialists.

While referring to this supporting overseas activity, let me mention some promotional activities we are carrying on abroad. Over 100 trade fair exhibits have been held in the past 5 years. These were attended by an estimated 45 million people representing foreign industry and foreign consumers. Large international exhibits have been held and will continue to be held in places such as London, Tokyo, and Paris. We look forward to November when Hamburg, Germany, will be the site of an agricultural show which will represent the greatest of our promotional effort and will be the first where commercial exhibitors will be on a large-scale basis. Some of you--and we wish many of you--will be able to visit the first overseas U. S. Trade Center which opened in June in London. This is a joint venture of the USDA and the Department of Commerce. The Secretary of Agriculture opened the first agricultural exhibit earlier this month.

Exhibits and trade shows will continue to be used to improve business overseas and so will all other tried and true techniques of selling including: Market analyses and research, advertising, demonstrations, distribution of samples, visits of foreign officials and buyers to the U. S. We shall do our utmost to see that no favorable approach is overlooked.

While I have properly placed considerable emphasis on dollar markets abroad, you are aware that our agricultural exports also go

to nondollar markets in considerable volume. The reference here is chiefly to Asia, Africa, and Latin America. These countries have varying degrees of dollar buying power. Some special government programs are brought into play to increase exports to them. One of the most potent of these is Public Law 480. In the fiscal year 1960-61 to which I have referred before, our nondollar exports were equal to $1.5 billion--approximately 30 percent of total shipments.

The government programs that play such a leading part in our agricultural exports are: (1) Sales for foreign currencies, (2) barter, (3) long-term credit sales for dollars, and (4) donations. Under all four of these programs the various difficulties of countries in securing from us the products so necessary for human needs as well as economic betterment are eased. All four of these programs make their varying contribution to market development. All four bring food within the reach of millions in quantities they could not obtain otherwise.

Pilot programs are underway in the long-term dollar credit program; barter has been used for marketing soybeans; and, as we all know, large quantities of vegetable oils have been sold for foreign currencies. The foreign donation program now brings further hope to people overseas who cannot freely meet their needs under our other basic marketing programs. The 100 million pounds of oilseed products covered in the first foreign donation allocation have now been purchased from U. S. firms. There will be further purchases for hungry people, and they will know--and clearly know--that what they receive comes from the friendly and peaceful people of this country.

We are now confident of a record yield per acre for soybeans and of a total supply of oilseed greater than this country has ever seen. We look forward to record export sales of both soybeans and vegetable oils. Record exports of the last few years will be exceeded. I am referring now only to sales for dollars and under government sales programs. The foreign donations program will account for exports over and above the record sales to be reasonably expected.

In the great potential that exists regarding use of oilseeds and their protein products in human foods, it should be clearly understood what we can do--and by so describing our capabilities, show what, as of today, we cannot do. The oldest and most thoroughly tested of all our market development work is to be found in Japan. In cooperation with the American Soybean Association we have carried on a highly successful effort for increased human consumption of soybeans and soybean protein with attendant nutritional benefits. Per capita-wise, the Japanese are consuming more vegetable oil than ever before and also are getting more protein into their diet through increased consumption of soybeans and the protein products of soybeans. Human consumption of soybeans in many forms is an historical situation in Japan, so the stage was somewhat set

for gratifying accomplishments as the impetus of a well-organized merchandizing project hit the Japanese market. The product we were able to push was a product in abundant supply and offered to the consumer at a price he could pay--the price being a few pennies per pound. Use was made of kitchen buses with their cooking demonstration, nutritional seminars, films, newspapers, radio, and all the familiar tools in advertising carried out in cooperation with Japan industry and government agencies. It is this sort of work we are set up to do and to the extent possible we will carry on similar work where ever similar circumstances occur.

Our major effort in our market development work is to create or expand markets for products which are in abundant supply and at prices which consumers can afford to pay. We are, of course, also interested in the development of new products. But here again, our interest in product improvement is aimed toward the development of markets for products which, even though not available currently in abundant supply at reasonable prices, give every promise of meeting these conditions in the near future. Therefore, we are extremely interested in nutritional research of the kind we are discussing today. And to a limited extent, we would be prepared to support the use of some of our market development funds to support overseas projects of this kind. In such research our primary interest would be the development of protein-rich foods available at the cheapest possible prices, prices which the masses of the underdeveloped countries could afford to pay.

All in all, I think that the Foreign Agricultural Service and the soybean industry are on the right track. Working together, we can do a great deal to assure good markets for American soybeans and products and a higher standard of living for consumers everywhere.

Session III

RESEARCH AND DEVELOPMENT ON SOYBEAN FOODS

Dr. John C. Cowan, Presiding
Chief, Oilseed Crops Laboratory
Northern Utilization Research and Development Division

PRESENT AND POTENTIAL USES OF SOYBEAN FLOUR, GRITS, AND PROTEIN CONCENTRATES IN FOODS

Wilbert E. Huge

Vice President, Central Soya Company

In the approximate 30-year history of the commercial development of soybeans in the U. S., many marketing problems have been encountered. The solution to such problems has been accomplished when product research and development provided the route to more effective utilization.

Early in the industry's history the transition was initiated from the old process to the new process type of oil extraction. The resulting protein product--a dusty, untoasted, meal--was at times virtually unsaleable for livestock and poultry feeds. Frequently much of the production found its way into the fertilizer market as a source of nitrogen, competing with all other sources of organic nitrogen of inedible quality. Continued exhaustive processing and product research has elevated this protein fraction of the soybean to a position of commanding importance in the livestock and poultry field and today it supplies more than 50 percent of all of the supplemental protein used in this field--more than 9 million tons annually.

Many of us have had the conviction that U. S. soybeans are on the threshold of performing a worldwide protein function similar to that which it has accomplished in the field of U. S. livestock and poultry production. While a part of this may be in the same animal feed area, undoubtedly, the complexities of need will much more importantly involve the edible uses of soybean protein. These products today fall in three general classifications--soybean flour and grits, concentrated soy protein, isolated soy protein.

Soybean flour has represented the bulwark of the edible soy protein field for many years, and while it has suffered some black eyes, in some areas in the past, it has generally survived the trials of occasional misuse. This basic low-cost source of edible protein has found a wide variety of application, even in such a food-rich nation as the U. S. Mr. Diser, who follows me on this program, will discuss with you, in detail, the use of soybean flour and grits as protein supplements for cereal products. In addition, soybean flour and soybean grits have functioned as an efficient low-cost source of protein in variety meat products and other foods.

You will recall that the evolution of soybean protein meals for livestock and poultry feeds traced a course from the 41-percent protein expeller meal--through the various stages of improved technology in

the cooking and toasting of 44 percent protein-extracted meal--and culminated in dehulled low fiber 50 percent protein-extracted meal. There may be some parallel to this history now evolving in the edible soybean protein field. While for many years the 50 percent + protein soy grits, or soy flour, have been the standards in this field, there appear specialized needs requiring different characteristics of a functional nature and/or organoleptic nature, which are opening new markets for specialized types of soy protein products.

This area generally involves two classifications--soy protein concentrate--over 70 percent protein on a dry basis, is produced by the removal of virtually all of the oil and water-soluble nonprotein constituents. Isolated soy protein--exceeding 90 percent protein, on a dry basis, is virtually free of all nonprotein components. We do not visualize these two products competing with soy flour, or soy grits, for the same markets. Economically this is not possible, since they obviously will always be more costly, even on a protein unit basis. However, we would visualize that they will serve to open new markets for soy protein, by reason of their wide potential range of physical characteristics, their stability under extremes of storage conditions, and the obvious economics of transportation and handling advantages of this more concentrated source of protein. Most certainly, if the forecast trips to the moon are to be accomplished within the next 10 years, isolated soy protein may very well be the beefsteak in the diet of the crew on that first space ship.

I would not wish to represent that no problems accompany the production of these two new protein materials--nor would I maintain that optimum value can be realized if the products are misused.

However, biological experiments, to date, provide some guideposts concerning the routes which may be effectively pursued in the proper utilization of these products. Since neither animals nor humans consume a diet of single protein source, the most efficient use of proteins suggests combinations which utilize the best qualities of each. This has long been an accepted principle in animal feeding. Therefore, if we wish to approach the human feeding subject on a scientific basis, do not similar principles apply? Therefore, in determining practical uses for the various soy proteins, we must examine their strengths and their weaknesses. Table 1 lists the average amino acid analysis of Protein 70 and of Promine.

For the purpose of simplicity, I am using the trade names for these products, that is, Protein 70--to designate the concentrated soy protein, and Promine--to designate the isolated soy protein. As you will observe from this table, both soy proteins are deficient in the sulphur-containing amino acids. To those conversant with the history of soybean protein in animal feeding, this comes as no surprise. Recognizing this deficiency, and determined to avoid misuse, we must find the areas of proper use, and the qualities which make such use possible.

Table 1.--Average amino acid analysis

	Grams per 16 grams nitrogen	
	Promine	Protein 70
Lysine	6.28	6.28
Threonine	3.70	4.01
Cystine	.96	1.21
Methionine	1.10	1.33
Valine	5.16	5.27
Isoleucine	5.03	4.93
Leucine	7.92	7.84
Tyrosine	3.81	3.69
Phenylalanine	5.46	5.12
Histidine	2.41	2.65
Arginine	8.06	7.56
Aspartic acid	11.98	11.58
Serine	5.40	5.02
Glutamic acid	20.26	18.48
Proline	5.31	5.22
Glycine	4.11	4.23
Alanine	3.99	4.28

Table 2 lists the essential amino acid pattern of protein requirement of man, as established by the FAO, as well as the level supplied by toasted soy grits, Protein 70 and Promine.

Table 2.--Soy proteins amino acids compared FAO pattern

	Milligrams amino acid per gram nitrogen			
	FAO	Toasted soy grits	Protein 70	Promine
Lysine	270	383	392	392
Threonine	180	258	251	231
Methionine	144	81	83	69
Total methionine and cystine	270	161	159	129
Valine	270	302	329	322
Isoleucine	270	297	246	315
Leucine	306	490	428	495
Tyrosine	180	238	231	238
Phenylalanine	180	323	320	342

Since Promine analysis indicates lower levels of several essential amino acids, the search for strengths and weaknesses of the soy proteins suggests examination of this area. The experiments from which I will quote hereafter involve feeding of each ration to four groups of four rats each. Amino acid analysis of Promine, when compared with the amino acid requirements of the rat, shows the following deficiencies when fed at the critical assay level of 10 percent protein.

	Percent
Methionine......	0.29
Lysine..........	.27
Threonine.......	.13
Isoleucine......	.05
Valine..........	.03
Tryptophan......	.02

Table 3 lists 4-week gains and protein efficiency when amino acids were added at the levels of indicated deficiency. As you will note, compensations were introduced to accomplish a biologically effective level, recognizing the source of the added amino acid.

Table 3.--Effect of amino acid supplementation of Promine on rat growth and protein efficiency

	Ave. 4-week gain (grams)	Protein efficiency
Promine	24	1.02
Promine + methionine	41	1.43
Promine + methionine + lysine	79	2.26
Promine + methionine + lysine + tryptophan	80	2.36
Promine + methionine + lysine + tryptophan + threonine	132	3.32
Promine + methionine + lysine + trytophan + threonine + isoleucine	132	3.27
Promine + methionine + lysine + tryptophan + threonine + isoleucine + valine	143	3.61

Amino acids added at following levels as percent of diet:

	Percent
dl - Methionine	0.29
l - Lysine	.27
dl - Tryptophan	.04
dl - Threonine	.26
l - Isoleucine	.05
dl - Valine	.06

The dramatic response to this simple amino acid fortification suggests that this soy protein has inherent possibilities of vast potential.

Experiments to date reveal no significant response to heat treatment of Promine. This appears to be part of the evidence indicating that in the course of processing, the natural inhibitors present in the soybean have been largely removed. Since methionine appears to be the first limiting amino acid, further experiments with methionine additions, beyond minimum requirements, produced satisfactory gains in protein efficiency with no other amino acids added. Table 4 records these results, both at the 10 percent protein level and the less critical 15 percent protein level.

Table 4. Effect of methionine supplementation of Promine on rat growth and protein efficiency

	Ave. 4-week gain (grams)	Protein efficiency
<u>10% Protein in Diet</u>		
Purified casein	96	2.49
Promine	27	0.87
Promine + 1.5% methionine	92	2.40
Promine + 2% methionine	93	2.49
<u>15% Protein in Diet</u>		
Purified casein	153	2.42
Promine	57	1.31
Promine + 1.5% methionine	133	2.24
Promine + 2% methionine	152	2.49

Since soy proteins in food applications will in most instances be subjected to heating, the effect of cooking, or toasting, is an area of needed knowledge. Table 5 demonstrates that heat-treated Protein 70 compares favorably with toasted soy grits, and with purified casein. One might assume, therefore, that Protein 70, like meal, flour, and grits contains some trace of inhibitor, whose affect is minimized by introduction of heat. In addition, each of the materials in this experiment responded similarly to methionine additions.

Table 5.--Effect of methionine supplementation and heat treatment of Protein 70 on rat growth and protein efficiency

	Ave. 4-week gain (grams)	Protein efficiency
Purified casein	79	2.32
Purified casein + 0.1% methionine	130	3.23
Toasted soy grits	90	2.43
Toasted soy grits + 0.1% methionine	122	2.97
Protein 70	63	2.09
Protein 70 + 0.1% methionine	114	2.87
Protein 70 + 0.15% methionine	120	3.09
Heat-treated Protein 70	92	2.48
Heat-treated Protein 70 + 0.1% methionine	132	3.12
Heat-treated Protein 70 + 0.15% methionine	137	3.24

Recalling the earlier expressed theory concerning protein use from a variety of sources, results outlined in Table 6 confirm the improved efficiency of various combinations of protein sources. The meat meal used in this experiment was ground, dehydrated, hexane-extracted beef round. When this meat meal was reduced in this manner to its protein component, the effective cost of the protein exceeded $5 per pound.

Table 6. Supplementary effect of Promine and meat meal on rat growth and protein efficiency

	Ave. 4-week gain (grams)	Protein efficiency
Purified casein	69	1.78
Sodium caseinate	58	1.75
Meat meal	87	2.08
Promine	20	0.58
Promine + 0.15% methionine	94	2.11
90% Meat meal + 10% Promine	115	2.58
90% Meat meal + 10% sodium caseinate	110	2.53
75% Meat meal + 25% Promine	98	2.33
75% Meat meal + 25% sodium caseinate	110	2.53

One might well draw some parallels with the current stage of edible soy proteins and the history of soybean protein in animal feeds. In each case, one might suggest recollection of Marshall Foch's statement, when he said:

> "There are no hopeless situations, there are only men who have grown hopeless about them."

If men had grown hopeless 25 years ago over the dusty, untoasted, extracted soybean meal, there would not be 9 million tons of high-quality soybean meal used today as the protein keystone in animal feeds.

While my assigned subject does not include the subject of philosophy, it seems to me that this Conference seeks to weld into a potent force--the scientist--the businessman--and the humanitarian. When reflecting upon the comments of this afternoon's speakers, one cannot help but be disturbed at the shallow thinking of people who refer to our agricultural abundance as a burdensome surplus, or a glut. As we seek means of utilizing our agricultural abundance more effectively, surely not even the most dull person would fail to recognize how fortunate are we of this nation.

I should like to repeat a brief part of my testimony on this subject, before the Senate Foreign Relations Committee, more than 2 years ago.

> "It is a commonly accepted principle that with any privilege there must be associated responsibility. This nation has the privilage of enjoying the most abundant food supply in world history. Is it not, therefore, our responsibility to find distribution methods whereby this abundance might be used in the world constructively?
>
> "I believe this is our responsibility as a Christian nation, and we may find a parallel to this subject in the story of the Eight Talents as recorded in the 25th Chapter of Saint Matthew. We might also remind ourselves of the admonition contained in Verse 40, of the same Chapter of Saint Matthew, which reads: 'Inasmuch as you have done it unto one of the least of these My brethren, you have done it unto Me.'"

Discussion: In view of the low efficiency of Promine *vs*. soy flour, the question was raised as to why we should promote protein isolates. In answer it was stated that isolates have applications where flour is not used, and is therefore supplementary--not necessarily competitive. The comment was also made that soy protein supplemented with methionine can be sent to Guatemala cheaper than 30-cent chicken.

SOY FLOUR AND SOY GRITS AS PROTEIN SUPPLEMENTS FOR CEREAL PRODUCTS

Gleason M. Diser

Soybean Research Council, National Soybean Processors Association

Throughout a period of nearly 50 centuries millions of oriental people have relied upon soybeans and products derived from them for the primary source of protein in their diet. Recently, increased interest has developed in the nutritive value of soybeans and other sources of plant proteins which may be used in the human diet to partially replace or extend animal proteins, such as milk, meat, and eggs. Various oilseed products have been developed for this purpose in the different areas of the world where proteins of animal origin are in short supply or nonexistent. Soybeans and their products continue to receive special emphasis in this field of application since they are adapted to a wide range of soil and climatic conditions and can be economically produced in many areas of the world.

Soybeans offer excellent possibilities as a source of supply of a large quantity of excellent quality protein which is suitable for use in many ways as human food (23). Soy flour and soy grits are being produced in large quantities for human consumption. Soybean protein, in the form of flour or grits, is being used in ever-increasing amounts in a wide variety of food products (9).

It will be the twofold purpose of this paper to (a) review the literature on the value of soy flour and soy grits as protein supplements for cereal products, and (b) present recent data from experiments conducted in the research laboratories of the major producers of these soya products to further demonstrate their value in improving the nutritional level of the human diet when they are used in conjunction with cereals.

Numerous investigations have been conducted to determine the nutritional value of the protein in the soybean.

The literature on the nutritive value of soybean protein has been reviewed in an excellent manner by Barnes and Maack (3), the Soybean Nutritional Research Council (68), Evans and McGinnis (15), and the various contributors to Markley's "Soybeans and Soybean Products" (Volumes I and II) (42, 43), and Altschul's "Processed Plant Protein Foodstuffs" (1).

As early as 1912, Mendel and Fine (46) found that human adults could utilize the nitrogen very well from soybean protein. Later, in 1917, Osborne and Mendel (51) presented experimental data which indicated that it was necessary to adequately heat soybean meal in the presence of water before the meal would support normal growth in

rats. These investigators were of the opinion that this improvement in the meal was due entirely to improved palatability resulting from the heat treatment. During the period 1930-40 numerous researchers (29, 30, 36, 58, 60, 67) demonstrated that the protein in properly heat-treated soybeans and soya products had a high nutritive value. The experiments of Hayward and his coworkers (31) and numerous other investigators of that period clearly demonstrated the direct relationship between the nutritive value of soya products and the heat treatment which they receive during processing. Innumerable reports may presently be found in the literature in which investigators have presented data confirming the work of the early researchers in establishing the superiority of properly processed soya products as a source of protein in the diet of humans, as well as in rations for livestock and poultry (4, 15, 16, 19, 28, 40, 44, 45, 47, 57, 59, 62, 66).

There is ample evidence in the literature (5, 34, 41, 50, 65) that cereal proteins, especially the protein of wheat, are deficient in the two essential amino acids--lysine and valine. Since the protein from the soybean provides an excellent means of overcoming the inherent deficiency of these two amino acids (22), the use of soy flour and soy grits in bread formulation and in conjunction with other cereal products has been and is presently receiving widespread attention. Full-fat or defatted soy flour (prepared by the solvent-extraction method), as defined and described later, has been used almost exclusively in these applications.

Hafner (22), Kuiken and Lyman (39), and others (27) have pointed out the comparatively high level of lysine and certain of the remaining essential amino acids in the protein of the soybean. This comparative abundance of these amino acids, contributed by the soy flour or other soya products to a mixture of soya and cereal, makes up for the amino acid deficiencies commonly found in the proteins of cereals. Figure 1 shows the comparative amounts of the various amino acids contained in defatted soy flour and in some cereals commonly used in the human diet. It is interesting to note that defatted soy flour or soy grits excels each of the 3 cereals--corn, wheat, and rice--by containing considerably more of the 8 essential amino acids as shown in this graph. In this chart the comparative values for lysine are undoubtedly the most important in terms of potentiality for the human diet. Defatted soy flour supplies some 10 times more lysine than any of the 3 cereals. Wheat and corn are equally deficient in lysine, with rice containing slightly more of this amino acid. Corn is notoriously deficient in the very important amino acid, tryptophan. Wheat contains twice as much as corn but rice supplies only a trifle more than corn. Soya contains only about 3-1/2 times more tryptophan than wheat but about 9 times more than corn. It is generally conceded that even a properly processed soy flour does not contain a sufficient amount of methionine in terms of the requirement for humans and animals. Nevertheless, the combination

of methionine and cystine for soy flour results in quite an impressive figure in comparison with the 3 cereals, that is: 4-1/3 times more than wheat and nearly 6 times greater than corn or rice. This combination of values for cystine and methionine, in view of the sparing effect of cystine on methionine, appears to account for the favorable protein efficiency as determined by a biological assay of soy flour.

Edwards and Allen (13) used whole egg as a standard in rating various mixtures of cereal and soya as a source of the essential amino acids. "When 100 grams of a food contained 100% or more of the quantity of the amino acid in 100 grams of whole egg, the food was rated as an excellent source of that amino acid. Similarly, if the food contained 75 to 99% of the quantity of the amino acid in whole egg, it was rated as a good source. Those foods listed as fair sources contain 50 to 74% of the amino acids in whole egg, whereas poor sources contain less than 50%." They rated a soya-corn combination as an excellent source of all the essential amino acids except methionine and tryptophan. However, they reported that this specific combination was a good source of these two amino acids, rated on the basis of 75 to 99 percent of the quantity in whole egg.

Brown _et al_. (8) studied the effect of lysine supplementation on the protein efficiency of breads containing high levels of protein. Various combinations were evaluated in which the percentage of protein from wheat varied from 89 to 60 percent and that from milk and soy flour from 11 to 40 percent. When the protein quality, as indicated by grams of gain per gram of protein consumed by white rats (protein efficiency ratio--"PER"), was measured for this range of combinations, the data showed that protein quality was directly correlated with the lysine content of the mixed protein. This was true in all instances, regardless of whether the lysine was a constituent of the protein or was added as a supplemental source.

Ericson (14) investigated the possibilities of improving the nutritive value of Swedish white bread through supplementation with certain amino acids. The nutritive value of the protein was measured by growth rate and gain in weight per gram of protein consumed by male weanling rats. It was found that the addition of lysine and threonine improved the nutritional quality of the bread protein considerably more than the addition of lysine alone. No further improvement was demonstrated when methionine, valine, and tryptophan were added to bread diets already supplemented with lysine and threonine.

In 1935, Bailey, Capen, and LeClerc (2) reviewed the literature on the use of soy flour in conjunction with cereals. They also reported their observations, from the standpoint of nutritional value and bakery standards, on the evaluation of soy flour as an ingredient in bread formulas.

Horvath (32) reviewed the early nutritional studies on the use of soy flour in bread which demonstrated the supplemental effect of additions of 10 to 30 percent of soy flour to the formulation. Jones and Divine (37) also reviewed the early nutritional evaluation of soy flour as a bread ingredient. Much of the more recent work pertaining to the effect of low percentages of soy flour on the nutritional quality of bread protein has been reviewed by Carlson and her associates (10). Shuman (61) has also prepared a very good review on the importance of soy flour as an abundant source of low-cost protein for use in the human diet.

There has been a considerable amount of work reported specifically on the supplementary effect of soy flour on the protein of wheat flour (10, 37, 64). Recognition of the valuable amino acid composition of the protein in soy flour when combined with the proteins of wheat flour and milk in the formulation of bread, as reported by Harris et al. (26) and others, has made it increasingly important to study the value of the edible grades of soy flour as a source of supplementary protein when used in white bread.

Jones and Divine (37) found that supplementing patent flour with different amounts of soy flour increased the PER for white rats from 0.75 for the patent flour to 1.38, 2.16, and 2.27 when 5, 10, and 15 percent, respectively, of the soy flour was added.

Johns and Finks (35) reported a PER of only 1.0 for rats fed wheat bread. When comparable rats were fed a soya-wheat bread the PER was increased to 1.5.

A similar improvement in the protein quality of bread, resulting from the addition of soy flour, was demonstrated by Kon and Markuze (38). The results of their rat-growth studies showed an average PER of 1.0 for bread made with unsupplemented wheat flour whereas the PER was increased to 1.62 when soy flour was added to the bread formulation.

Rat-growth studies were carried out by Carlson and her associates (10) in determining the effect of soy flour and dried nonfat milk solids on the nutritional quality of the protein in white bread. The data from their studies showed that bread supplemented with 3 percent of soy flour was equal in nutritive value to bread containing 3 percent of milk solids and significantly better than bread without any protein supplement. The addition of 5 percent soy flour to the formula resulted in bread that was at least equal in nutritive value to bread containing 6 percent of milk solids and significantly better than whole wheat bread and the unsupplemented bread.

Growth studies with rats were carried out by Volz and his coworkers (64). Diets were fed containing white bread and white bread with 5 percent of soy flour added. The growth-promoting

value of the white bread, which contained 3 percent of whole milk solids, was significantly improved by the addition of 5 percent of soy flour. The white bread, which contained 3 percent of milk solids, produced a PER of 0.97, whereas the bread with 5 percent of soy flour (and containing an equal amount of milk) gave a PER of 1.17. Similar studies made by these investigators, in which the flours were compared before being made into bread, showed an average PER of 0.80 for patent flour and 1.13 for patent flour with 5 percent of soy flour added.

Harris et al. (26) found that the protein in bread containing 3.0 percent skim milk solids with 3.0 percent of soy flour added was superior in nutritive value to that of bread formulated with 6 percent skim milk solids.

Bricker, Mitchell, and Kinsman (7) demonstrated the supplementary relationship between the protein in soy flour and that in wheat flour in metabolism studies with human subjects. They reported a biological value of 41 for white flour and 55 for a 1:9 mixture of soy flour and white flour.

Light and Frey (41) reported that white bread of high nutritional value could be produced by the use of low-fat soy flour to replace a portion of the white flour, thus taking advantage of the comparatively high level of lysine in the soy protein to supplement the wheat protein.

Research by Hove, Carpenter, and Harrel (33) showed that the protein from soybeans (as soybean oil meal) exhibited a marked supplemental effect on the protein in both patent flour and whole wheat flour. In their studies, patent flour produced a PER of 0.84, whereas additions of 10 and 20 percent of soya increased the PER to 1.59 and 2.06, respectively. Rats fed whole wheat flour under the conditions of their experiments gained at the rate of 1.40 grams per gram of protein consumed (PER). Additions of 10, 20, 35, and 50 percent of the soy protein produced PER values of 1.94, 2.35, 2.45, and 2.53, respectively.

Sure (63) used white rats to study the enrichment of the proteins in cereal foods by the addition of small amounts of food materials with a high protein content. Dry food yeasts, low-fat soy flour, dried nonfat milk solids, and peanut meal were evaluated by this researcher. He reported that improved growth, reproduction and lactation resulted from the substitution of as little as 1, 3, or 5 percent of these protein supplements for equivalent amounts of white corn meal or enriched refined wheat flour in the diet of the rats. He postulated that the improvement in the nutritional efficiency of the diet "was due to the provision of lysine, tryptophan, and possibly other dietary factors."

Cravioto and associates (12) compared the biological values of the proteins of maize (corn), tortillas, and tortillas made with maize and soy flour. Their conclusions were based on the results of 7-week rat-growth studies with diets containing approximately 7.2 percent of protein. Feeding a diet composed of tortillas containing 10 percent of soy flour resulted in a PER of 1.8. Corresponding values for tortillas without soy flour and for maize alone were 1.0 and 1.05, respectively.

Reynolds and Hall (56) studied the effect of adding soy flour on the protein value of baked products (cakes, pastry, and cookies). The formulas used were those provided by commercial bakeries for the respective products. The soy flour was added at levels varying from 6 to 10 percent. The results of their study showed that the soy-supplemented products, when fed to rats, produced superior growth, improved protein efficiency, and increased nitrogen retention in every instance in comparison with the nonsupplemented products containing an equal level of protein.

It is not within the scope of this paper to discuss in any detail the effect of the functional properties of soy flour and soy grits on the physical characteristics of bread and other baked goods in which they are used. However, it should be pointed out that Bohn and Favor (6), Ofelt _et al_. (48, 49), Glabau (20), and numerous other investigators (17, 18, 21, 53, 54, 55) have studied in considerable detail the effect of these sources of soy protein on odor, flavor, volume, grain and texture, and color in bread and other bakery products.

Soy flour has been defined as the screened, graded product obtained after expelling or extracting most of the oil from selected, sound, clean dehulled soybeans (27). However, full-fat soy flour, as described later, contains all of the oil originally present in the soybeans since it is not passed through presses or subjected to solvent extraction during processing.

Generally speaking, all soya products are referred to as "flour" if they are ground finely enough to pass through a No. 100 U. S. standard screen. Soy grits are usually classified as "coarse," "medium," or "fine" within the limits of the following granulations as determined by the majority percent of the sample passing through the respective U. S. standard screens:

	Numbers
Coarse......	10 to 20
Medium......	20 to 50
Fine........	50 to 80

Depending upon the texture desired in the finished product, soy flours and soy grits are generally used interchangeably in the preparation of foods.

There are four general types of edible-grade soy flour presently being manufactured in the United States to meet specific needs (27).

Defatted soy flour is produced by the nearly complete removal of the oil from soybeans through the use of hexane and usually contains 1 percent or less of fat (ether extract).

Low-fat soy flour is produced either as a result of partial removal of the oil from soybeans or by the addition of soybean oil to defatted soy flour at a specified level, usually in the range of 5 to 6 percent.

High-fat soy flour is produced by adding soybean oil to defatted soy flour at a specified level, usually in the range of 15 percent.

Full-fat soy flour contains all of the oil originally present in the raw soybeans, usually from 18 to 22 percent.

Lecithinated soy flour is also being manufactured by some processors in limited amounts for specific food uses. This type of flour is produced by adding soybean phosphatides (lecithin) to defatted soy flour at a specified level, usually in a range up to 15 percent.

In Table 1 typical or average analyses are presented for some of the different types of soy flours and grits described above (27).

Table 1.--Composition of soy flours and grits

	Defatted soy flour and grits	Low-fat soy flour and grits	Full-fat soy flour
	Percent	Percent	Percent
Protein (N x 6.25)	50.5	46.0	41.0
Fat (ether extract)	1.5	6.5	20.5
Fiber	3.2	3.0	2.8
Ash (minerals)	5.8	5.5	5.3
Carbohydrates (total)	34.2	33.5	25.2

Depending upon the amount of moisture in the atmosphere, the moisture content of soy flour and grits will vary from 5 percent to as much as 10 percent, with the average usually in the range from 5 to 8 percent.

The calcium content of these soya products varies from 0.25 to 0.26 percent while the phosphorus content falls within a range from 0.58

to 0.65 percent (27). Sodium, potassium, magnesium, and the trace minerals (iron, copper, cobalt, zinc, etc.) are also present in varying, but appreciable, amounts.

The carbohydrate fraction of soy flours and grits contains approximately 5.5 percent of sucrose and from 20 to 29 percent of polysaccharides (complex sugars). There is barely a trace of starch present (27).

Thiamine (vitamin B_1), riboflavin, and other water-soluble factors of the vitamin B complex are present in these soya products in varying amounts. The lecithin fraction of soy flours and soy grits contains inositol and choline. The lecithin or mixed phosphatide portion of these soya products varies within a range from 1.6 to 2.5 percent. Other fat-soluble vitamins or vitaminlike substances, such as carotene and tocopherols are also present (27).

It must be emphasized that the analytical data presented in Table 1 and the discussion immediately following the tabular presentation are considered to be "typical averages." These values may vary considerably from analytical data for particular products under specific conditions.

As Hayward and Diser (27) have pointed out, "these analyses are generally used as a basis for determining which of the soya products available is best suited or most easily adapted for a particular application. In addition, specifications have been developed in the trade which clearly define the characteristics desired to further pinpoint the ability of a certain product to meet requirements, mostly physical, found to be desirable for a specific purpose. These soya products are purposely modified during processing to give the functional properties desired for the intended use of the flour or grits."

Defatted or full-fat soy flours have been used almost exclusively in the numerous experimental applications discussed above.

It has been conclusively shown that the nutritive value of a protein is dependent upon the kind and the amount of amino acids which it supplies to the body of the individual consuming the protein. Since proteins vary to a considerable extent in their digestibility, absorption from the digestive tract and utilization for body functions, the determination of the comparative nutritional quality of a protein, as used for food, is a problem of exceptional complexity.

The method most commonly used for evaluating protein quality was originally proposed by Osborne, Mendel, and Ferry (52) in 1919. This biological method is based on the determination of the ratio, generally referred to as "protein efficiency ratio" (PER), of gain in body weight in grams to grams of protein consumed by growing rats fed a diet in which the protein is the only factor limiting growth.

This biological method for assaying protein quality has been and is presently being used in the research laboratories of the major manufacturers of soy flour and soy grits in the United States as a tool to determine the effect of various processing procedures, etc. on the nutritional value of the end product. In addition, this technique has been widely used to demonstrate the supplemental effect of the protein of the soybean on the cereal components of the diet. In some instances, slight revisions or modifications of the method have been made but the basic technique is essentially that described by Osborne and his associates.

The remainder of this paper will be given over to the presentation and discussion of data, largely unpublished, made available to the writer by personnel of the major companies involved in the processing of soy flour and soy grits. These data are from experiments either conducted in their own facilities or in independent laboratories at their request.

The data to be presented and discussed here is from experiments which demonstrated the supplemental effect of soya on the cereal portion of (a) bread, (b) graham crackers, (c) cookies, (d) rolled oats, and (e) macaroni-spaghetti products.

One of the experiments (72) was designed to demonstrate the effect of soy flours, which had received different degrees of heat treatment during processing, on the nutritional value of bread. The different soy flours were incorporated into the bread formulation at the level of 3 percent on the basis of the wheat flour. The loaves of bread were baked at 425° F. for 30 minutes, with the internal temperature of the loaf at 205°-207° F. for at least 15 minutes. The bread was air-dried at room temperature, ground, and incorporated as such into the diet of male weanling albino rats. Bread containing 3 and 6 percent dried nonfat milk solids as a source of supplemental protein was also evaluated in this study. The level of protein in the assay diet was 10 percent and the feeding trial was carried on for 6 weeks with six rats maintained in individual cages in each experimental lot. The results of these experiments are presented in Table 2.

Table 2.--Effect of heat treatment during processing on the supplemental value of soy flours in bread

Bread	Protein supplement	Heat treatment	PER
Basal white water bread	None	0	0.80
Basal white water bread	Milk solids (3%)	0	.91
Basal white water bread	Milk solids (6%)	0	.96
Basal white water bread	Soy flour (3%)	Light	1.01
Basal white water bread	Soy flour (3%)	Full	1.01

Under the conditions of this experiment, the degree or amount of heat treatment received by the soy flour during processing had no effect on the nutritional value of the bread made with the respective samples of soy flour. The addition of 3 percent of either of these flours resulted in bread that was significantly higher in nutritional value than the unsupplemented bread and as good as or slightly better than bread containing either 3 or 6 percent of dried nonfat milk solids as a supplemental source of protein.

The effect of various levels of fully cooked ("toasted") soy flour in the formulation on the nutritive value of standard white bread has been recently reported (25). The soy flour was substituted for equivalent amounts of wheat flour in the commercial formula for standard white bread. A comparison was also made with the nutritive value of a commercially produced "high-protein" bread. The data from this study is summarized in Table 3.

Table 3.--Effect of adding various levels of a fully cooked soy flour on the nutritive value of standard white bread

Bread	Protein supplement		PER
	Source	Amount	
		Percent	
Standard white bread	Milk solids	4	1.17
Standard white bread	Soy flour	5	1.25
Standard white bread	Soy flour	10	1.83
Standard white bread	Soy flour	15	2.06
Standard white bread	Soy flour	20	2.21
High-protein bread	--	--	1.68

These data serve to illustrate very effectively the definite supplemental effect of various increments of soy flour on the nutritional value of wheat flour in bread. In this particular instance, the addition of 10 percent of soy flour to the standard white bread formula produced a bread with a higher nutritive value, as indicated by the increased PER, than the "high-protein" bread, even though the protein levels in the two breads were essentially the same (10.7 and 10.2 percent, respectively).

Carlson and her coworkers (11) demonstrated that graham crackers to which soy grits had been added were markedly superior in nutritional quality to regular graham crackers. In this study the graham crackers were fortified by substituting 30 percent of defatted soy grits for an equivalent amount of the graham flour.

The effect of the addition of soy grits to cookies, made on the basis of a commercial formula, has also been studied (70). The addition of the soy grits exerted a significantly beneficial effect on the nutritive value of the cookies. The experimental animals (rats) fed the cookies fortified with soy grits gained, on the average, about 59 grams during the 42-day test period, whereas the rats fed on the unsupplemented cookies actually lost weight during the course of the test.

A protein assay with rats was conducted to determine the supplementary effect of soy grits at the 5-percent level on the protein of rolled oats (60). The rolled oats and the mixture of rolled oats-and-soy grits were assayed both in the raw and cooked forms. The sample of soy grits used in this study was a "lightly cooked" product, having received only a minimum of heat treatment during processing. A definite supplementary effect was shown when 5 percent of soy grits was added to rolled oats and the resultant mixture cooked. Neither cooking alone nor adding raw soy grits had any effect on the protein quality of the oats. The cooked oats-and-soya mixture was shown to have a nutritive value equal to that of dried nonfat milk solids.

Other investigations (71) have demonstrated the supplemental effect of soy flour on the cereal flour (semolina) commonly used in the manufacture of macaroni-spaghetti products. The results of these studies are presented graphically in Figure 2. In each instance, the cereal or cereal-soya mixture was made into simulated macaroni, thoroughly cooked (in boiling water for 12 minutes), washed in cold water, air-dried, ground, and fed in the assay diet to weanling male rats. The meat was a mixture made up of equal parts of beef, chicken, and pork which had been thoroughly cooked during the canning process. Hayward and Diser (27) have stated that "the data from these studies show how the nutritional value of a cereal-and-soya mixture can be made to equal, or surpass, that of meat protein by the addition of increasing increments of soy flour."

Obviously, the outstanding ability of soy flour and grits to adequately supplement the proteins of the various cereals is based on the relatively high content of excellent quality protein in these soya products. The amino acids in the protein from the soybean serve very effectively to supplement or compensate for the amino acid deficiencies found in the protein of the cereal. This has been presented graphically in Figure 1 and the data reviewed and reported in this paper serve to confirm this theoretical approach most conclusively.

Attention is specifically invited to the fact that the results of the more recent experiments confirm in every instance the data reported by the earlier researchers from their investigations on the supplemental effect of soya products on the proteins of cereals. It is most interesting to note that the magnitude of the protein

efficiency ratios reported by the more recent investigators for unsupplemented breads as well as for bread formulations supplemented with various increments of soy flour are quite comparable to those found as a result of research carried out during the period 1930-55.

An interesting and significant observation has been made regarding the effect of the heat treatment received by soy flour during processing on the nutritional value of the bread into which it is incorporated. As previously shown, the degree or amount of heat treatment which a soy flour receives during processing has no significance as to the effect exerted by the soy flour on the nutritive value of the bread in which it is used. This serves to confirm the point that it is not necessary to use a fully cooked soy flour in the formulation for those foods which receive a sufficient amount of heat treatment during the preparation or baking process (e.g., bread, cakes, rolls, etc.) to render the protein in the soya biologically available for maximum nutritional value. However, in those instances where foods receive little or no cooking in preparation for consumption, a thoroughly cooked soya product must be used in order to provide the full advantage of its optimum supplementary effect on the cereal proteins or other components in the diet.

It has undoubtedly been noted that all, or practically all, of the data reviewed and presented in this paper have been collected from feeding trials and assays in which rats were used as the experimental animals. There are those who feel that more research should be conducted with human subjects to adequately demonstrate the supplemental effect of these soya products on the other components of the diet. It is agreed that this type of research should definitely be encouraged.

However, we must not ignore the many instances in which soy flours and soy grits are presently being used fairly extensively as components of the diet of children and adults.

In various public and private institutions (e.g., prisons, mental hospitals, children's homes, homes for the aged) these soya products now serve as a low-cost source of excellent protein in feeding programs. In institutions of this kind, the use of these products aids substantially in improving the plane of nutrition as well as the economy of caring for the inmates.

Soy flours and soy grits, in addition to providing an economical source of excellent protein for feeding people in public and private institutions, serve very effectively as a source of dietary protein in those areas of the world where protein is at a premium for food purposes as well as in the feeding of refugees and displaced persons. These products are finding increased utilization in special diets for children and adults and in conjunction with treatment for certain diseases. In the alleviation of allergenic conditions, these

products can be used very effectively as a source of protein in the diets of people who are allergic to the protein in wheat, eggs, and other foods (27).

Soy flours and grits, on the basis of their low starch content, serve a definite purpose in the diet of persons who are suffering from diabetes. Soy flour has been effectively utilized in many recipes that have been developed and are being used successfully in diabetic diets under physicians' orders (27).

As prepared in the western world and other areas, "soy milk" is usually a dispersion in water of a powdered mixture consisting of a properly processed soy flour (preferably a full-fat flour), carbohydrates, minerals, vitamins, and, in some instances, a flavoring compound. In addition to becoming widely used as a food for infants suffering from malnutrition, this "soy milk" serves as a source of excellent quality protein for individuals afflicted with certain allergies, diabetes, and other diseases associated with their diet.

The literature covering the nutritional value of the protein from the soybean has been reviewed. Specific data showing the supplemental effect of the protein from soy flour and soy grits on the protein of cereals have been emphasized. Information has been presented with regard to the content of the essential amino acids present in these soya products in comparison with some of the more commonly used cereals--corn, wheat, and rice.

Soy flour and grits have been defined and the types and/or kinds available described and discussed. Analytical data have been presented on the composition of the different types of soy flour and grits, including protein, fat, fiber, ash (minerals), carbohydrate and vitamin content of these products.

Data, largely unpublished, as made available from the laboratories and technical sections of the major producers of soy flour and soy grits, has been presented and discussed. These data have demonstrated the supplemental effect of soy flour and/or soy grits on the protein of cereals as used in bread, graham crackers, cookies, and other cereal-soya mixtures commonly used as human foods.

The data presented and reviewed during the course of this discussion have definitely shown that, when properly processed, soy flour and grits serve as a source of protein that is comparable in nutritive value, or very nearly equivalent, to meat and milk. From the standpoint of economics these soya products can provide this excellent quality protein at a much lower cost in most instances than protein from animal sources. In addition, as has been demonstrated time after time, soy flour and grits exert a marked supplementary effect on the cereal proteins so that cereal-and-soya mixtures are comparable in nutritional value to the protein from animal sources.

The question now arises as to how this specific information regarding the supplemental effect of soy flours and soy grits on cereal proteins may be applied in an attempt to alleviate the present protein deficit in various areas of the world.

It has been pointed out (27) that "many of the foods indigenous to most of the countries of the world are either low in protein or contain protein of poor nutritional quality." In addition, in many countries, cow's milk cannot be produced or imported in sufficient quantity to meet the nutritional requirements of infants, young children, and pregnant and nursing mothers. Older infants and children in these areas need protein-rich foods besides milk in their diet for optimum growth and development.

In order to qualify for use in the diet in areas where the economy is underdeveloped, protein-rich foods must be (a) of excellent quality, (b) low in cost, (c) readily available, and (d) easily prepared for consumption.

It may be possible in some areas to increase the availability and consumption of foods of animal origin. However, in a majority of the areas of the world, increases in population will result in insufficient land acreage being available to support an animal agriculture in the magnitude that will be required to satisfy the nutritional requirements (principally protein requirements) of the increased number of people. In those areas where foods of animal origin, i.e., meat, milk, eggs, are available only in limited amounts, such products are usually beyond the economic reach of those people whose need for them is greatest. In such areas, the only practical solution to the prevention of protein malnutrition is the better and wider utilization of protein from vegetable sources, such as soy flour and grits.

Cereals can be produced in most areas at a comparatively reasonable cost per unit of nutrient. Unfortunately, these foodstuffs are composed largely of carbohydrates which can be used only for energy. Proteins are present in cereals in relatively small amounts and, as has been shown, are of definitely poor quality from the standpoint of composition and balance of amino acids. However, in those areas where milk and other sources of animal protein are either nonexistent, uneconomically available or in short supply, soy flours and/or soy grits can be combined in the proper ratios with cereal proteins to provide food mixtures whose nutritional value is comparable to the protein in foods from animal sources.

The writer wishes to express his sincere appreciation to his friends and associates in the soybean processing industry for being selected to represent them in the presentation of this paper. Special appreciation is due those who contributed data from their files for inclusion in this presentation and samples of their products to be displayed in the exhibit which has been set up in conjunction with this Conference on "Soybean Products for Protein in Human Foods."

Discussion: Two questions were raised: If fully cooked soy flour is good, why use lightly cooked soy flour? Are there any nutritional bad effects? In answer it was stated that lightly cooked flour gives better loaf volume, color, and some other properties. Soy flour for use in many cooked food products is essentially uncooked. Raw soy flour, however, makes sticky dough. The question of high nutritional value combinations by addition of small quantities of soy flour to large amounts of cereal flour was answered to the effect that quantities of soy flour up to 25 percent have been added in the case of semolinas to improve nutritional value.

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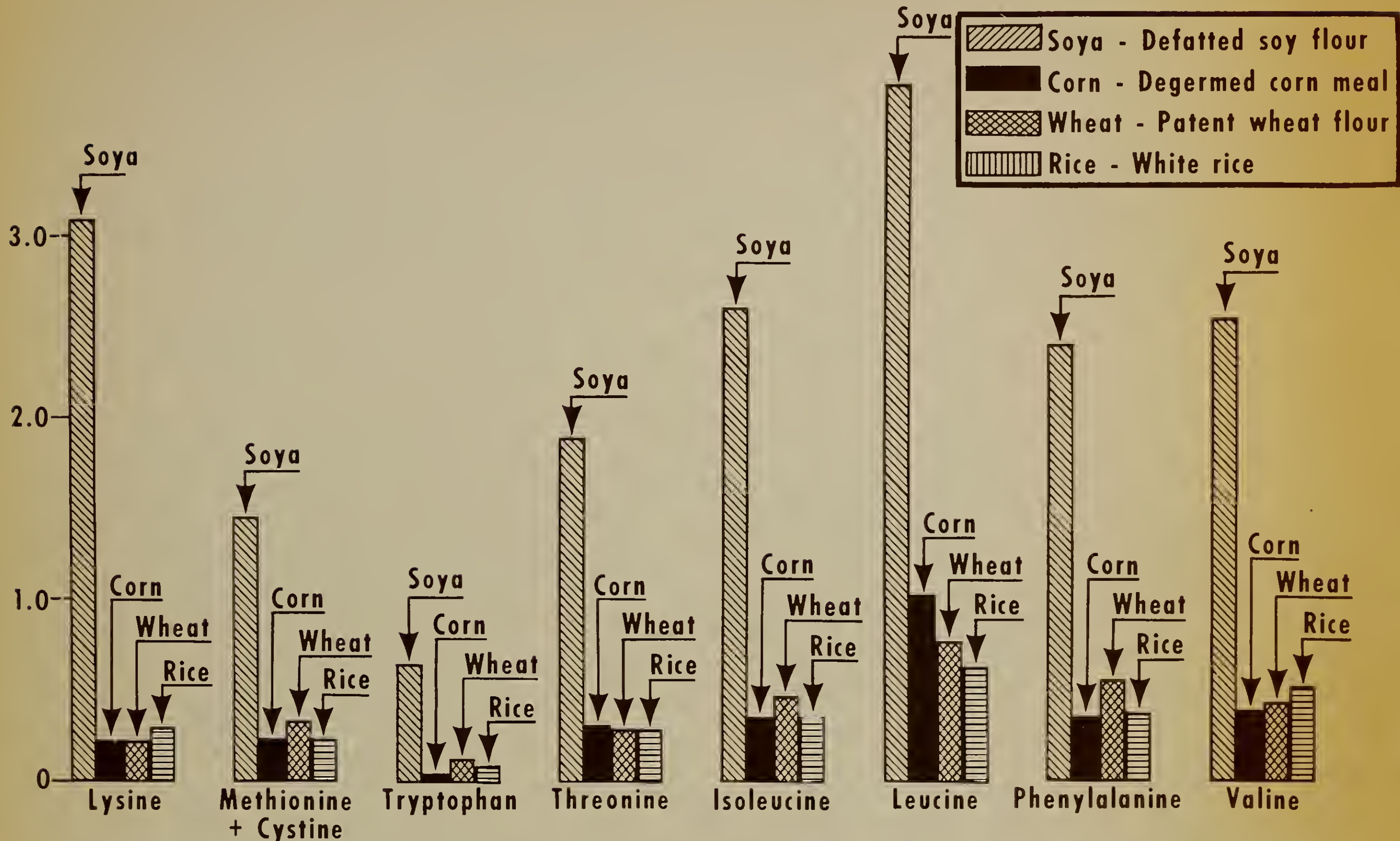
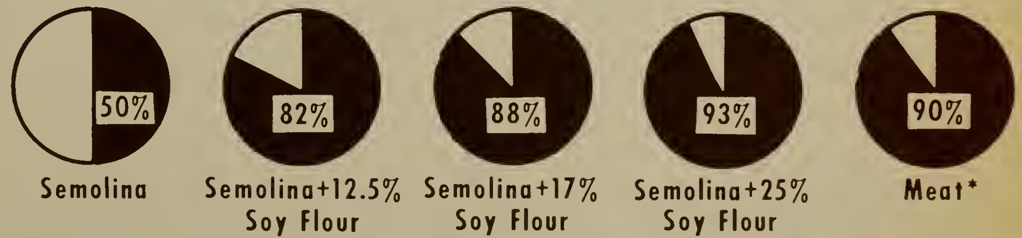
Amino Acid Composition of Soy Flour and Some Cereals Commonly Used in the Human Diet (grams of amino acid per 100 grams of food)



Reference: Orr, M. L. and B. K. Watt. "Amino Acid Content of Foods," Home Economics Research Report No. 4 (Dec., 1957), ARS, U.S. Department of Agriculture

Figure 1.

Supplemental Effect of Soy Flour on the Nutritive Value of Cereal-Soya Mixtures



Relative Protein Efficiency based on dried nonfat milk solids = 100%
*Mixture of equal parts of beef, pork and chicken

Figure 2.

RESEARCH AT NORTHERN REGIONAL RESEARCH LABORATORY ON FERMENTED FOODS

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Three types of fermented foods have been investigated at the Northern Regional Research Laboratory, namely, soya sauce, miso, and tempeh. The first was studied shortly after World War II and the others have been studied within the last 2 or 3 years. The three fermentations have in common a mold fermentation of soybeans with the soybeans being altered by the enzymes produced microbiologically.

The soya sauce process is a fermentation in which rice and wheat are added in small amounts to soybeans. During the process rice is molded with special strains of *Aspergillus oryzae* and the fermentation is carried out with strains of a yeast, *Hansenula*, and a lactic bacterium, *Lactobacillus delbrueckii*. The final product is a brown colored liquid with a pronounced flavor and a free amino nitrogen content of 0.45-0.5 percent. The process flowsheet is shown in Figure 1. The fermentation process is carried out widely in the Orient, especially in China and Japan. An alternate method is the acid hydrolysis of soybeans.

The next most important fermented food made from soybeans, at least in Japan, is miso or soybean paste. Miso is a food prepared by the fermentation of mold rice and soybeans with the addition of salt. Our work was initiated to try to discover improved methods for the manufacture of miso to overcome some of the objections to American soybeans imported into Japan for miso. The objections raised were the nonuniform nature of U. S. soybeans resulting from the mixture of various varieties, causing a lack of uniformity in absorption of water; a lack of uniform cooking; and consequently irregular fermentation of the soybeans. In addition, the color of U. S. soybeans was not the same. Some beans have seedcoats that have black or dark areas, others are greenish in color. This work was supported by the American Soybean Association, the Foreign Agricultural Service of the U. S. Department of Agriculture, and the Japanese-American Soybean Institute of Tokyo.

Miso is used principally to make soup that takes the place of our cereal for breakfast. It is also used as a flavoring agent with various foods, including vegetables and meats. It is reported that the total annual production of miso amounts to over 900,000 metric tons, equivalent to a daily consumption of about 28 grams per capita per day. It is, thus, an outlet of considerable importance for soybeans. Miso may even find some use as a flavoring agent outside the Orient.

Information available in English on this important fermentation was very scanty; practically all were brief accounts from the Department of Agriculture. For example, in a recent detailed account on industrial microbiology only six lines are devoted to the subject, with a single reference. It was apparent that not only did we need to examine the possibilities of improving methods of processing American soybeans, but that we should learn as much as possible by studying the process and make this information available in English. As a consequence, we have prepared three technical papers--two of which have been published and the third accepted for publication. In addition, we have prepared a review paper on miso and have been issued one public service patent (see Appendix).

The miso fermentation as carried out traditionally in Japan consists of the following steps. Polished rice is washed, soaked, steamed, and inoculated with Aspergillus oryzae and placed in shallow wooden trays. It is necessary that the rice remain moist enough for mold growth, but not so moist that bacteria can grow. The rice is held for 48-50 hours until the mold has covered all the grains of rice completely throughout the mass but has not developed temperatures of much over 40° C. and has not produced the green color typical when sporulation occurs. Growth of the mold beyond this stage results in a moldy flavor. The koji or mold rice serves as a source of enzymes for the digestion of the soybeans and also makes simple sugar available in the second stage of the fermentation. At the same time the koji is being prepared, whole soybeans are washed, soaked in water, drained, and steamed. The steamed soybeans and mold rice are mashed lightly together and, at the same time, sodium chloride is added. These three ingredients are inoculated with an appropriate amount of miso mixed with water to act as a starter. The mixed material--salt, inoculum, steamed soybeans, and mold rice--are packed tightly into a container and covered. The fermentation is allowed to go on at 28° C. for one week; then the temperature is raised to 35° C. and continues for several months. Thus the fermentation is anaerobic and consequently the mold on the rice is killed by the salt and the lack of oxygen and is replaced by a fermentation of anaerobic osmophilic organisms introduced with the old miso as inoculum. During fermentation there is a gradual darkening of the substrate and a change in the odor. At the end of the fermentation the material is allowed to ripen for 2 weeks at room temperature, then it is removed and ground into a paste. It is then ready for sale. Different types of miso are prepared by varying the ratio of mold rice or mold barley to soybeans, the amount of salt, and the length of the fermentation. The purpose of the salt is to act as a preservative. If it were not present a dangerous anaerobic bacterial fermentation would occur. Because of this high salt content, most types of miso may be kept for considerable periods of time even without refrigeration.

Initially we explored the possibility of preparing miso on a small laboratory scale. Once suitable equipment had been devised, a

number of small fermentations were run on a number of varieties of soybeans. It was obvious that the rice and its preparation as mold rice, the inoculum of Aspergillus oryzae, did not play an important role as far as solving the problem was concerned. Study of the preparation of the soybeans with regard to the uniformity of cooking and the time required for soaking showed a great deal of variation between different lots of soybeans. As one would expect, there were some varieties which were superior to others in certain characteristics such as uniformity of absorption of water, cooking, and color. However, to use certain varieties for this fermentation would add to the cost of export.

In carrying out the preliminary small fermentations we devised, or modified, three pieces of equipment. The first was a cooker in which the amount of pressure could be controlled and which was also arranged so that live steam could be blown through the beans to remove the beany flavor. This is shown in Figure 2. A second piece of equipment was a glass container with a wide mouth and a tight fitting lid to carry out the actual fermentation. Since the product is a paste it is essential to have a wide-mouthed jar for packing the substrate for fermentation and for removing it at end of fermentation. The third piece of equipment was a penetrometer modified to determine the hardness of individual soybeans.

The difficulty with soybeans appeared to stem from the seedcoat, for it is this structure which has the varied colors; it is also the seedcoat that prevents some beans from absorbing water. This, in turn, prevents adequately uniform softening of all beans during cooking, thus preventing uniform fermentation. It was found that if the seedcoat was removed and then the remainder of the bean was cracked into four or five pieces, soaking and cooking times were more uniform. Consequently, the entire fermentation was uniform regardless of what mixture of soybean varieties, either U. S. or Japanese, was fermented. This method greatly reduced the actual time involved in soaking, cooking, and fermentation. The process as developed requires that the beans not be broken up too fine. Small-scale fermentations using finely ground grits or flour all resulted in failure. The process of preparing miso as developed in our laboratory is shown in Figure 3 (from Developments in Industrial Microbiology 2: 205. 1961).

From a microbiological viewpoint, the miso fermentation has a second obvious weakness. When the substrate is prepared for fermentation good miso from a previous fermentation is used as a source of inoculum. A review of the literature on this point gives one the impression that this type of mixed inoculum must be used since a number of species of bacteria and yeasts are required to give a proper fermentation.

It should be noted here that the Culture Collection got its start in the Department about 1900 when Charles Thom was hired to

investigate the various mold cheeses. It was from his isolation of pure cultures and his publications, at least in part, that the mold cheese industry got its start in the United States.

It seemed highly desirable to attempt to isolate into pure culture those microorganisms which were essential to the miso fermentation and to exclude those forms which play no role in the process. Consequently, I plated out on appropriate media the miso received from Japan as a starter, as well as samples of miso from our own fermentations. Plating media were used which would select various lactic bacteria, osmophilic and halophilic bacteria and yeasts. After making a number of such streakings and dilutions of the miso, we came to the conclusion that the only regularly encountered organism that was present in large numbers was a typical osmophilic yeast. Microscopic examination of miso also showed yeast cells but relatively few bacterial cells. Dr. Wickerham identified this yeast as Saccharomyces rouxii Boutroux, a heterothallic yeast which has been reported elsewhere (J. Bact. 80: 492-495. 1960). This yeast has a number of synonyms, including S. soya, Zygosaccharomyces soya, Z. japonicus var. soya, and Zygopichia japonica.

The use of a mixed inoculum as practiced widely in the manufacture of miso has obvious disadvantages. Contaminating microorganisms which will grow in the fermentation will be carried from one fermentation to the next. Secondly, since most forms of miso require months for fermentation, followed by ripening, it is obvious that the proper microorganisms required for the fermentation will be reduced in number and vigor and, therefore, a longer period of time is required for them to initiate active growth and multiplication. This is especially true under conditions of reduced oxygen availability.

To test the use of pure culture methods, small fermentations were carried out as before except that the inoculum used as a starter was a pure yeast culture of S. rouxii NRRL 2547. The inoculum was prepared by growing this strain (one which had been isolated from a good miso) on yeast extract-malt extract agar slants. This inoculum was then used to inoculate Erlenmeyer flasks containing 0.3 percent yeast extract, 0.3 percent malt extract, 0.5 percent peptone, 10.0 percent NaCl, and distilled water. Thus the inoculum was a vigorous growing pure culture adapted to a high salt content as would be encountered under actual miso fermentation conditions. In practice, the medium could be an extract from soybeans with a high salt content. The remainder of the fermentation was carried out in the same fashion as before with soybean grits. As a control the fermentation was performed in the usual fashion, that is, with miso from a prior fermentation as inoculum. The results of the pure culture fermentations were far better than we had anticipated. Pure culture inoculum fermentations had a strong yeast and ester odor in less than 4 days, while the control showed

no obvious signs of fermentation in this time but after 8 days did give indications of an active fermentation. Throughout the fermentation time the pure culture fermentation was farther advanced than the controls. Another conspicuous difference was the fact that the controls, because they had carried along a variety of forms of microorganisms, developed a typical dirty white mycelial growth form over the surface of the substrate which was typical of all fermentations using miso as inoculum. The pure culture fermentation, on the contrary, showed very little of the oxidative yeast phase growth even at the end of the fermentation. When fermentation was complete 100-gram samples were taken of pure culture fermentation and control and were sent to Dr. Shibasaki's laboratory in Japan for evaluation. His results were as follows:

Comparison of miso fermented with a pure culture of *Saccharomyces rouxii* NRRL Y-2547 and with miso from a previous fermentation*

	Uninoculated medium	*S. rouxii* NRRL Y-2547	Miso used as inoculum
Moisture	52.0	56.2	58.0
Total nitrogen	1.89	2.03	2.05
Soluble nitrogen	0.67	1.49	1.28
Amino nitrogen	.13	0.50	0.52
Total acid calc. as lactic acid	.57	1.05	1.12
Reducing sugars calc. as glucose	11.05	9.17	10.01
pH	5.7	5.12	5.0

* From Applied Microbiology 9; (1961). In press.

A taste panel in Japan indicated that the pure culture fermentation compared favorably in taste, appearance, and odor with traditionally prepared miso. I am convinced that miso may be prepared in a wholly satisfactory manner using a pure culture of *S. rouxii*, such as NRRL Y-2547 as a starter. Culture inoculum appears to work with whole soybeans as well as grits. It also follows that with proper selection of yeast strains one could find strains which would give even more rapid fermentations, differences in flavor, etc. Since this yeast is heterothallic, that is, + and - strains when brought together result in sexual reproduction and consequent segregation of genes, the possibilities of the production of useful crosses is almost unlimited. Thus a strain with ability to grow and ferment faster could be mated with one producing more flavor or odor, resulting in a haploid cross that would

grow and ferment faster and, at the same time, produce better flavor. Once a desirable haploid cross was found it could be maintained indefinitely through asexual reproduction.

A third fermentation of soybeans which we have studied most recently is the Indonesian fermented soybean food called tempeh or tempe. We were fortunate in having Mr. Ko Swan Djien from the Laboratory of Microbiology, Institute of Technology, Bandung, spend part of last year with us in the study of this fermentation. Since he was acquainted with this food and we had cultures available, we began with a study of the pure culture fermentation paralleling the actual process as carried out in Indonesia. The flowsheet of the process on a laboratory scale shown in Figure 4 is as follows:

1. Soybeans are washed and soaked overnight in tap water at 25° C.

2. The seedcoats of the soaked beans are removed by hand if a small amount is to be prepared. In doing so, the beans are split into two halves and the seedcoats are discarded.

3. The two halves of the beans are then boiled without pressure in excess water for 1/2 hour.

4. Remove the beans onto towels to drain off the excess water and to cool the beans, which are now swollen and soft.

5. After cooling and draining, the beans are inoculated with spores of the tempeh mold (*Rhizopus* sp. NRRL 2710). A few ml. of sterile water are added to a slant of the sporulated culture and 1 ml. of this spore material will be more than adequate to inoculate two petri dishes of beans.

6. After the beans have been inoculated and mixed, they are packed into petri dishes. It is important to pack as many beans as possible into each dish and to tie the lids down. If the beans are not packed tight the mold will sporulate; this is not good.

7. The inoculated beans in petri dishes are then placed in an incubator at 31°-32° C. for about 20 hours.

8. At 20-24 hours the entire dish should be filled completely with white mycelium and the entire contents can be lifted out as a round disc. Some sporulation may occur at the edge of the dish; this is all right.

9. This mass of mycelium and beans is then sliced into thin slices about 1/2 cm. or less in thickness, dipped into salt water, and fried in a vegetable fat. The slices will become a golden brown color and are delicious when hot. One may want to salt to suit one's taste and some like to add soya sauce to the hot, crisp slices.

In Indonesia the fermenting mass of soybeans is wrapped in banana leaves with a volume not much greater than the fermentation as carried out in our laboratory. This fermentation has certain distinct advantages, namely, it is a very short fermentation time, a very acceptable food product is made, and the whole process is relatively simple. However, the food has several disadvantages--including the ease of contamination and short keeping time of the finished product.

As noted above, the organism used in making tempeh is *Rhizopus* and we have at least 4 species which, under suitable conditions, are capable of making acceptable tempeh. However, the typical *Rhizopus* used in Indonesia is a species on which no name can be conclusively attached. A good representative form is NRRL 2710. We have received 50 or more strains from various sources from tempeh and we are quite sure that NRRL 2710 is the typical organism. It most certainly is not *R. oryzae*, which is mentioned in the literature. A name more appropriate is *R. oligiosporus* Saito which certainly was based on the typical tempeh organism. This name may be a synonym of an earlier name and, therefore, we have only tentatively used the name *R. oligiosporus*, reserving the right after further study to use an even earlier name, such as *R. chinensis* Saito if this proves to be the case.

Since this fermentation will be the subject of the next speaker, I will not discuss it further.

In the work reported, I would like to acknowledge the persons with whom I have worked, namely, Dr. K. Shibasaki of Tohoku University in the study on miso, Mr. Ko Swan Djien of Indonesia in the tempeh study, and the interest of Dr. A. K. Smith of the Oilseed Crops Laboratory, as well as various assistants in my laboratory. Without the firsthand knowledge of the fermentations, supplied by our fellow workers from Japan and Indonesia, it would not have been possible to carry on this work. One needs always to know in starting work on any of the Oriental fermentations exactly how the product is produced under actual manufacturing conditions and how the food appears and tastes. Once one knows the technology, one can examine the process from a scientific standpoint and apply modern microbiological principles to the study of the process and its improvement.

APPENDIX

Publications and Patents of Northern Utilization Research and Development Division on Fermented Foods from Soybeans

Publications

Miso. I. Preparation of Soybeans for Fermentation.
K. Shibasaki and C. W. Hesseltine
J. Biochem. Microbiol. Technol. Eng. 3(2): 161-174. July 1961.

Bacteriol. Proc. (Soc. Am. Bacteriologists): 49-50. 1960. (Abstract)

Miso. II. Fermentation.
K. Shibasaki and C. W. Hesseltine
"Developments in Industrial Microbiology" 2: 205-214, Plenum Press Inc., New York. 1961.

Miso. III. Pure Culture Fermentation with *Saccharomyces rouxii*.
C. W. Hesseltine and K. Shibasaki
Appl. Microbiol. 9: 1961 (in press)

Heterothallism in *Saccharomyces rouxii*.
L. J. Wickerham and K. A. Burton
J. Bacteriol. 80(4): 492-495. October 1960.

The Production of Chinese Soya Sauce.
L. B. Lockwood
Soybean Dig. 7(2): 10-11. October 1947.

In Preparation

Miso Fermentation.
K. Shibasaki and C. W. Hesseltine
Econ. Botany

Tempeh Studies.
Ko Swan Djien and C. W. Hesseltine

Indonesian Fermented Foods.
Ko Swan Djien and C. W. Hesseltine

Patent

Preparation of Miso.
Allan K. Smith, Clifford W. Hesseltine, and Kazuo Shibasaki
U. S. Patent 2,967,108. Issued January 3, 1961.

Flow Sheet for the Production of Soya Sauce

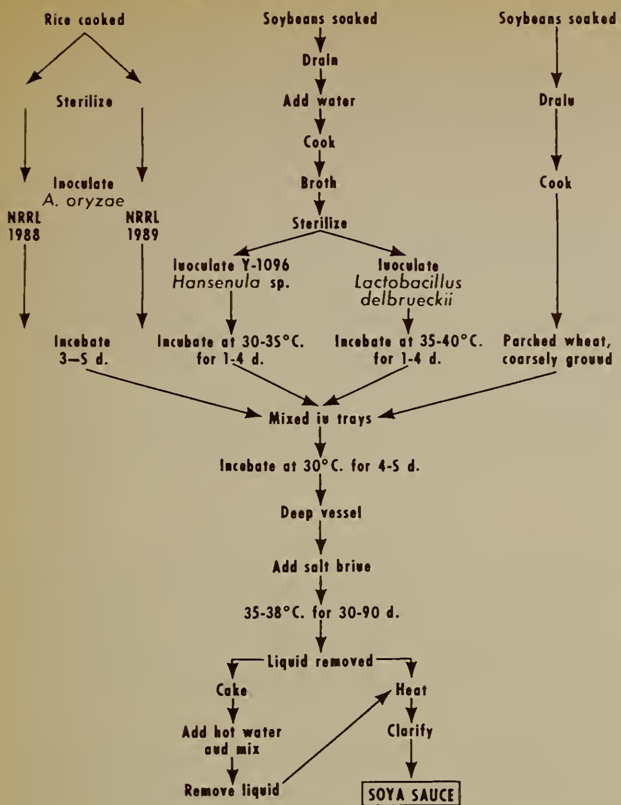
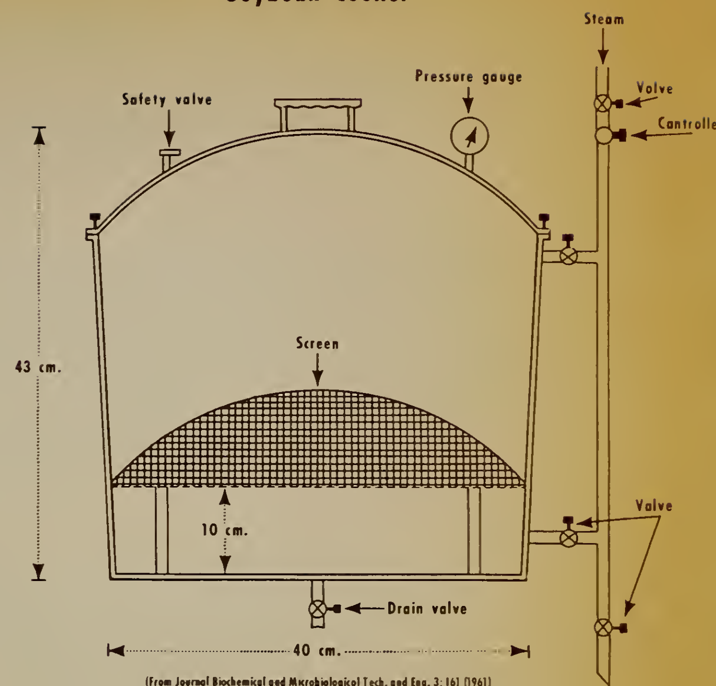


Figure 1.

Soybean Cooker



(From Journal Biochemical and Microbiological Tech. and Eng. 3; 161 (1961)

Figure 2.

Flow Sheet for the Production of Miso from Grits.

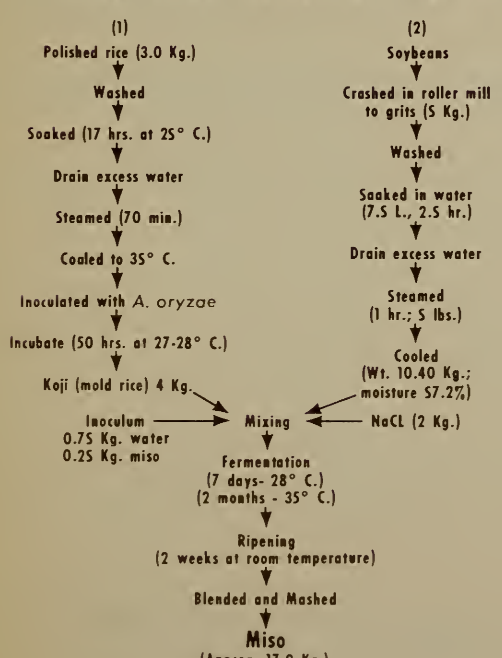


Figure 3.

Flow Sheet for the Production of Tempeh

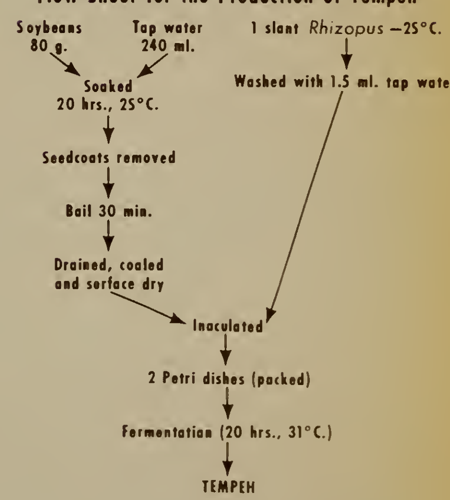


Figure 4.

PILOT PLANT STUDIES ON TEMPEH[1]

K. H. Steinkraus,[2] D. B. Hand, J. P. Van Buren, L. R. Hackler
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Soybeans have been an important source of protein in the Orient for centuries. Examination of the Oriental pattern of usage shows that the soybeans are consumed only in small quantities in unmodified form. In very nearly all cases, the soybeans are either fractionated or modified by fermentations, generally with molds, but sometimes with bacteria, yeasts, or mixtures of microorganisms. Well-known examples are soybean curd, soy sauce, miso of Japan, and Indonesian tempeh.

Tempeh, produced by fermenting soybeans with a species of *Rhizopus* mold, has been suggested as a possible source of low cost protein for child feeding programs in underdeveloped countries (Autret and van Veen 1955). van Veen and Schaefer (1950) suggested that tempeh is more easily digested than the original soybeans.

Production of tempeh in Indonesia is on a home or small-scale basis. The product must be adapted to modern commercial methods if it is to play an important part in child feeding programs for the world.

It was decided, therefore, to investigate the tempeh fermentation, determine the factors controlling mold growth, and secure the information needed to set up controlled fermentations on a relatively large scale.

Indonesian Method of Tempeh Production

By the Indonesian method, medium sized yellow soybeans are soaked overnight in fresh water. The soak water is discarded and the beans are washed. Fresh water is added and the beans are boiled one hour. The cooking water is discarded and fresh water is added. The hulls are scraped off with the feet or hands. Many loosened skins are left mixed with the beans. Some may be skimmed off. Fresh water is added and the beans are soaked overnight. During this soak, a bacterial, acid fermentation occurs. The soak water is discarded and the beans are steamed 90 minutes. The beans are cooled to about 37° C and are inoculated with mold from a previous fermentation. The inoculated beans are wrapped in banana leaves and placed

[1] This investigation was supported in part by a Grant from the United Nations Children's Fund.

[2] Paper presented by Dr. Steinkraus.

in a warm place to ferment. After about two days the beans are covered with mold. The acid odor is gone and the tempeh is ready to cook. The product keeps for several days.

By a shorter Indonesian process, the dry beans are heated in water for one hour and then are soaked overnight. The skins are then loosened and partially removed from the beans by skimming. The beans are then steamed an hour and a half, cooled and inoculated. Except for bacterial, acid fermentation of the soybeans during soaking, the mold is the predominant organism in the tempeh fermentation. The mold is, however, undoubtedly accompanied by various bacteria and other microorganisms as the product is made in Indonesia.

Tempeh is generally eaten fresh but it is also preserved by slicing and sun drying.

The Indonesians cook tempeh for consumption either by deep fat frying thin slices or cut the tempeh into cubes and use it as a substitute for meat in soups.

Changes in Soybeans Fermented to Tempeh

In our initial studies on tempeh, it was found that a natural bacterial fermentation during soaking was variable. Sometimes the beans became acid; sometimes they did not. It was found that a tempeh with typical odor, flavor, and bean cake characteristics (determined by an Indonesian student working on the project) could be produced by soaking the soybeans in dilute lactic acid solution and eliminating the variable bacterial pre-fermentation during soaking. This indicated that the tempeh mold was the essential microorganism of the tempeh fermentation. Our initial investigations therefore centered around changes in the soybeans produced by the mold. Recently, we have begun studies using a pre-fermentation during soaking in which *Lactobacillus plantarum* is inoculated into the soak water and produces the acidity needed to inhibit development of spoilage bacteria during the mold fermentation. It is obvious that pre-fermentation with Lactobacilli can cause changes in soybeans in addition to lactic acid production. Studies of these changes have been started but are not included in this report.

A. General Changes (Steinkraus et al, 1960-1961) - During the tempeh fermentation as the mold begins to grow rapidly, the temperature of the fermenting bean mass generally rises 5 to 7 degrees above the incubator temperature. The total soluble solids increase from approximately 13 to 28 per cent during a 72 hour fermentation. Soluble nitrogen increases from 0.5 to 2.5 per cent, while the total nitrogen remains relatively constant. The pH which starts out at about 5 in the soaked partially cooked beans rises progressively to above 7 and free ammonia is noted in the later stages of the fermentation.

During the fermentation, the mold digests the matrix between the soybean cells. The effect achieved is very similar to that produced by thorough cooking of soybeans. In both cases, the cells released from their surrounding material become very resistant to fracture. When beaten in a Waring blendor, the cells remain intact while raw soybean cells fracture very readily. It may be important to fracture the cells if tempeh is to be made into a milk for infant feeding.

B. Changes in Lipids (Wagenknecht et al, 1961) - The mold possesses strong lipolytic activity hydrolyzing over one-third the neutral fat during a 72 hour fermentation. The fatty acid composition of soybean tempeh was compared with that of cooked soybeans by means of vapor phase chromatography of the methyl esters. The neutral fat of the soybean was composed of palmitic, stearic, oleic, linoleic, and linolenic acids with linoleic acid predominating. The acids were liberated during the fermentation in roughly the same proportion as they occurred in the cooked soybeans. Except for depletion of some 40 per cent of the linolenic acid at the close of the fermentation there apparently was no preferential utilization of any particular fatty acid.

The acid number of the partially cooked soybeans (Seneca variety) was 1.7. At the end of 69 hours the acid number had increased to 78.3. In spite of the liberation of so much fatty acids, the pH showed a progressive increase to 7.3. This suggests that the mold was actively breaking down protein and deaminating the amino acids.

C. Changes in Carbohydrates (Shallenberger et al, 1961) - During the fermentation the principal change in carbohydrate is 1) the rapid removal of hexoses, and 2) the slow breakdown of stachyose. The mold will grow in an inorganic salts medium with ammonium sulfate as a nitrogen source when glucose, fructose, or galactose is supplied as a source of energy. It does not utilize sucrose or raffinose under the same conditions.

D. Changes in Lysine and Methionine - Both lysine and methionine assayed microbiologically show a decrease during the course of the tempeh fermentation (Table 1).

Table 1.--Changes in lysine and methionine during the tempeh fermentation

Amino acid	Milligrams amino acid/16 milligrams N		
	Start	36 hours	60 hours
Lysine	5.10	4.60	3.87
Methionine	1.41	1.36	1.25

E. Changes in Nutritive Value of Protein in Tempeh - György (1961) reported that the nutritive value of one lot of freeze dried tempeh prepared from Seneca soybeans was equivalent to skim milk and much higher than the unfermented soybean control. Unfortunately Seneca soybeans are no longer available commercially and this study cannot be repeated.

Tempeh prepared from Clark soybeans was harvested after 0, 12, 24, 36, 48, 60, and 72 hours fermentation, freeze dried, and fed to rats (10 per cent protein level) in an attempt to determine the amount of fermentation needed to develop optimum nutritive value. The rats found tempeh less palatable as shown by the quantity of food consumed as the fermentation progressed. Examination of the average daily weight gains suggests that the nutritive value of tempeh was decreased with increased fermentation time. However, the protein efficiency ratios remained very nearly the same throughout the course of the fermentation.

Additional samples of tempeh are being prepared for collaborative nutritive testing by Dr. Paul György at Philadelphia General Hospital and Dr. R. H. Barnes, Graduate School of Nutrition, Cornell University.

F. Changes in Vitamins and Other Factors Related to Nutrition - Since the nutritive value of the protein of tempeh did not appear to be appreciably higher than that of the starting soybeans, the investigation was broadened to include other factors such as vitamins and antibiotics that might be present in tempeh in higher quantities than they were in the starting soybeans.

Microbiological assays indicated that the vitamin content of tempeh is higher in certain cases and lower in others than the starting soybeans (Table 2).

Table 2.--A comparison of certain vitamins in soybeans and in tempeh

Vitamin	Concentration	
	In soybeans per gram	In tempeh per gram
Riboflavin	3 micrograms	7 micrograms
Pantothenate	4.6 "	3.3 "
Thiamine	10 "	4 "
Niacin	9 "	60 "
B-12	0.15 millimicrograms	5 millimicrograms

Tempeh and the tempeh mold were analyzed for content of antibiotics which might indirectly influence nutritive value. No evidence of any antibiotic activity was found either in extracted tempeh, extracted mold mycelium, or in the living mold toward _Bacillus cereus_, _Staphylococcus aureus_, _Escherichia coli_, or _Streptococcus_ species.

György (1961) reported that the mold produces an antioxidant which makes tempeh much more resistant to peroxide formation than soybeans.

Peroxide values were determined on the lipids extracted with ether (24 hours in Soxhlet) from samples of soybeans (control) and tempeh which had been dried, pulverized and stored for several months at room temperature. Peroxide numbers of tempeh samples ranged from 0 to 1.1 while peroxide numbers of soybeans handled under identical conditions, except for the fermentation, ranged from 18.3 to 201.9.

Advantages of Tempeh

Even though no clear nutritional advantage has been discovered so far for tempeh over the starting soybeans, the fact remains that millions of Indonesians have for centuries preferred tempeh over the cooked soybeans. There is the possibility that the Indonesians prefer the flavor of tempeh and nutritional value may not be involved. Or it may be that tempeh is more easily digested than soybeans since the proteins, fats, and other components have been altered during the fermentation. Tempeh may be less flatulence producing than soybeans. Another possibility is that fermentation, which effects changes in the intracellular and cellular structure of soybeans similar to prolonged cooking, results in sufficient savings in fuel to be important in countries whose fuel is in short supply. Finally, there is the possibility that the combination of flavor changes, pre-digestion of soybeans, easier cookability, improved stability of the dried product through antioxidant production, and possibly an increase in certain vitamins such as B-12 account for the Indonesian preference for tempeh.

Problems in Pilot Plant Production of Tempeh

Size Grading - Soybeans, even as the certified seed, contain a wide variety of sizes. In a recent shipment of certified Clark soybeans, the following distribution of sizes was obtained:

		Dry weight	
Screen size	Per cent of beans	Protein content, %	Ether extract, %
11/64	8	46.2	20.6
12/54	19	45.3	20.8
13/64	31	45.0	22.2
14/64	23	46.1	22.2
15/64	19	46.7	22.3

The variation in size requires that the soybeans be size graded before passing them through a burr mill to loosen the hulls. The variation among various sizes of beans in protein and lipid content and possibly other factors related to nutrition also presents a serious experimental problem when the objective is preservation of optimum nutritional value during processing.

Dehulling - It is essential to dehull the soybeans for the production of tempeh as the mold cannot grow acceptably on the intact beans. The beans have been successfully dehulled wet, loosening the hulls by passing the soaked beans through an abrasive vegetable peeler. The skins were then floated off in the water separating them from the cotyledons. The latter problem has not as yet been successfully solved on a pilot plant basis as it requires batch treatment and close, manual participation by the worker. There is need for a suitable mechanical dehuller that will work on wet soybeans.

Beans were dehulled dry very easily by passing the size graded soybeans through a burr mill after appropriate heat treatment. The loose skins were removed by passing the beans and hulls over a gravity separator (Oliver Manufacturing Company). At the present time dry dehulling shows the most promise as a commercial method.

Soaking - Either before or after dehulling, the soybeans must be rehydrated. Soaking losses are lower (approximately 1 to 2 per cent) in whole raw beans than in the dry dehulled beans (5 to 7 per cent). However, additional solids are lost during wet dehulling which may raise total losses to about 5 per cent of the solids not including the solids lost in the hulls themselves which approximate 9 to 10 per cent of the total soybean solids.

Soaking the whole beans may result in desirable chemical changes accompanying the early stages of germination. Some of these changes may be absent during soaking of dehulled beans and the quality of the resulting tempeh may be altered. It is important to maintain the pH of the soybeans at time of inoculation at a pH low enough to prevent the development of bacterial spoilage organisms but not too low to inhibit growth of the mold. Mold growth was not inhibited until the pH fell below 3.5. Growth of microorganisms causing spoilage was inhibited by soaking the beans in dilute lactic acid (30 ml. 0.85 per cent lactic acid per 3000 ml. water per 1000 grams of beans). The pH of the soybeans soaked and cooked in the dilute acid was about 5.0 at time of inoculation. This satisfactorily prevented growth of microorganisms other than the tempeh mold if other conditions were maintained satisfactorily for rapid mold growth.

Currently under investigation is the possibility of a prefermentation by Lactobacilli with lactic acid being produced eliminating the need for adding lactic acid during soaking to the soak

water. Preliminary results show that this can be accomplished satisfactorily. So far, the pH using Lactobacillus plantarum has been reduced to about 5.5 in a 15 hour pre-fermentation at 32° C. The effect of a pre-fermentation upon nutritive value has not been determined.

Cooking - A 90 minute cook at 100° C was found to be satisfactory for the production of tempeh. In initial studies dehulled soybeans were cooked in acidified soak water. Recently, the dehulled soybeans have been drained and steamed in wire baskets for the same time and temperature. If this procedure proves to be satisfactory, it could be adapted more readily to pilot plant production of tempeh where large wire baskets of the beans would be placed in retorts for cooking.

Tempeh has been produced from the raw, uncooked, dehulled soybeans. The tempeh mold did not grow as well on the raw beans and the tempeh produced did not have either the typical odor or flavor. It was found, however, that the 90 minute steaming is not essential. Shorter periods of cooking can result in typical tempeh. Additional studies are needed to determine whether or not there is an optimum cooking time for production of tempeh of highest nutritional value.

Inoculation of Beans with Tempeh Mold - The inoculum used for production of tempeh was isolated in pure culture from some tempeh brought to the United States from Indonesia. It was propagated first on a mixture of sterilized bran and soybean soak water. Later, sterilized soaked dehulled soybeans were used. In either case, the cultures were lyophilized after sporulation had occurred, finely ground, and added to the new tempeh fermentations as a dry powder or suspended in sterile water and sprayed on the beans. It is necessary to insure that the inoculum is well distributed over the beans by mixing them well after adding the inoculum.

Preservation of the tempeh mold to be used for inocula requires constant vigilance to insure that it does not become contaminated with similar, but different strains of mold, that it does not mutate, and that it does not contain bacteria which might spoil the tempeh.

Fermentation by the Mold

Qualities of the Tempeh Mold - The tempeh mold has been tentatively identified as Rhizopus oligosporus Saito (Hesseltine, 1961). Not all strains of mold matching the morphological description of the above species would be satisfactory for making a typical tempeh. The following characteristics have been found to be desirable for the strain of mold used to manufacture tempeh:

1. Rapid growth at 37° C; growth should be visible at 12 hours.
2. High proteolytic activity resulting in the release of free ammonia after 48 to 72 hours fermentation.
3. Ability to produce the typical tempeh odor, flavor and bean cake.

4. Inability to ferment sucrose.
5. High lipolytic activity.
6. Production of strong antioxidant.

Requirements for Mold Growth - The mold requires three factors in optimum quantities for rapid production of high quality tempeh from soybeans. These are oxygen, moisture, and heat. The various factors are closely inter-related and somewhat interdependent. The mold must have enough oxygen to permit rapid growth. However, if the air supply is too readily available, the mold metabolizes too rapidly and produces enough heat to injure its subsequent growth. Also, if air has too ready access to the fermentation chamber, some drying of the beans may occur and inhibit further growth of mold. If insufficient oxygen is available to the mold, growth will be sparse and the resulting tempeh poor. A very slow uniform diffusion of air into the bean mass appears to be optimum.

The beans must be fully hydrated to permit mold growth and the atmosphere within the fermentation chamber must maintain sufficient humidity to prevent surface drying of the beans which interferes with mold growth. On the other hand, if there is any excess moisture, growth of potential bacterial spoilage organisms is favored. An excess of moisture also prevents optimum oxygen diffusion into the beans and inhibits mold growth.

Growth of the tempeh mold is favored by an incubation temperature of 37°-42° C within the fermenting bean mass.

In devising pilot plant production of tempeh, the size of the fermentation chambers must take into consideration the diffusion of oxygen into the bean mass, the diffusion of heat out of the bean mass, and conditions necessary to maintain high humidity without permitting accumulation of water within the bean mass during the fermentation. It may be necessary to use a higher incubation temperature at the start of the fermentation and then a lower incubation temperature as the mold starts to produce its own heat.

Length of Fermentation - Taste panel studies indicated that a 36 hour fermentation was preferred by the majority of tasters. Many more analytical studies will have to be made to provide a basis for determining optimum length of fermentation.

Dehydration of Tempeh - Tempeh is perishable as it is harvested. Dehydration by hot air, freeze, or spray drying has been used to preserve the product. Hot air drying (69° C) reduced the solubility of solids and nitrogen in tempeh. Collecting the product after spray drying has proved to be a serious problem because the cells are intact and excessive losses occur in the spray drier unless a bag collector is used. The principal problem in preparing dry tempeh for use as a milk base is to develop a method for

rupturing the cells prior to spray drying. More investigation is needed to determine optimum drying conditions for preservation of highest nutritive value. Conditions for spray drying tempeh as a powder and cabinet drying of tempeh slices are going to be studied.

Summary

A considerable amount of investigation remains to be done before the tempeh can be produced in semi-commercial quantities under carefully controlled conditions. Although enhanced flavor, resistance to development of rancidity, and shorter cooking times are attributes of tempeh and may be responsible for the Indonesians fermenting their soybeans before consumption, it remains to be shown whether or not tempeh is improved nutritionally above the starting soybeans. In the development of a semi-commercial method for production of tempeh, the two crucial problems are: (1) Dehulling of soaked beans, and (2) developing a method for rupturing cells before spray drying.

Discussion: Cultures used in tempeh fermentation included both Dr. Hesseltine's selection and that brought by Miss Yap. Dr. van Veen commented on the preference of orientals for tempeh and other fermented soy foods rather than using soybeans directly. It is partly habit--in hot climates things ferment readily; also mature beans are noxious as a steady diet, resulting in digestive upsets.

The comment was also made that, where feasible, we should add human feeding to rat tests for nutritional values. The question was also raised as to possible trials of dry-dehulled soy grits for tempeh fermentation compared to wet-dehulled soybeans. At Cornell grits have not been tried because of aeration problems; splits might be used.

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FOREIGN RESEARCH PROGRAM OF U. S. DEPARTMENT OF AGRICULTURE ON SOYBEAN PROTEIN PRODUCTS UNDER PUBLIC LAW 480

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For many years, the Department has been financing with dollars a farm research program abroad. These investigations have been devoted to the search for biological agents useful in the control of insects and weeds, the study of animal diseases (such as African swine sickness, and foot-and-mouth disease), and to cotton breeding and seed increase activities. This program is very small as only 15 of our employees are residing abroad to carry on this work.

A considerable expansion of our foreign research program was effected a few years ago under Public Law 480. This program of research is financed with foreign currency accruing to the United States from the sale of surplus agricultural commodities, and, in a sense, trades surpluses for research results. Research in the field of economics, forestry, farm, marketing and utilization is carried out under this program. Projects are selected for financing which are of direct interest to the United States and also of interest to the foreign country. At the present time, 193 grants or research agreements have been executed in 20 countries in Europe, Asia, and Latin America. Funds are available to initiate programs in an additional 6 countries. Proposals from most of these countries are being processed at the present time. The annual cost of the grants already executed amounts to about the equivalent of $2-1/2 million in foreign currency annually. Substantial funds are available for the expansion of this program.

The Public Law 480 foreign research program is being administered by the Foreign Research and Technical Programs Division, Agricultural Research Service, U. S. Department of Agriculture, in Washington. A regional office has been established in Rome, Italy, to negotiate the costs of grants and administratively supervise the program in Europe and the Near East. A regional office has been established in New Delhi, India, also, to carry out the same functions in the Far East.

The technical phases of the program--that is, the approval of projects on which grants are executed and the review of progress reports--are handled by the various research divisions in the Department. For example, all projects on the utilization of

soybeans fall under our Northern Utilization Research and Development Division. All those dealing with the nutritional aspects of soybeans as a food are under the jurisdiction of the Institute of Home Economics.

Ideas for new research projects may come from within the Department, from research organizations abroad, from our Research and Marketing Advisory Committees, from national commodity organizations, or from the processing industry. We are indebted to The Soybean Council of America for the interest it has taken in developing our research program on soybeans abroad. The Council has stimulated many foreign research groups to submit projects on improving uses for soybeans. It has brought to our attention, also, important problems on soybeans that need attention.

In developing a program on soybeans we have been faced with the problem that most countries in which we have funds have had practically no knowledge or experience on the uses of soybeans, and have conducted very little research on their utilization. The opportunity has been very limited for financing research on the utilization of soybeans in laboratories with background experience on its products.

Fortunately, the activities of UNICEF and FAO, on increasing the protein level of the diet in the developing areas of the world, and the powerful market development program of The Soybean Council of America, have stimulated great interest in many countries on the usage of soy products in the diet. These efforts have facilitated the development of our research program on soy products.

As the primary emphasis of this conference is on soybean products for protein in human foods, the research work we are financing on soybean oil and fatty acids will not be discussed here. My talk will cover only those projects dealing with soybean proteinaceous foods, and with minor components in soy flour or soybean products which may affect their food value. A dozen or more projects of this kind, in half a dozen countries, are underway or will be shortly.

At the National Institute of Nutrition in Rome, Italy, we have executed a grant with Professor Visco to finance research on the use of soybean protein products as supplements to wheat flour in the production of pasta, such as spaghetti and macaroni. The southern part of Italy depends to a large extent upon cereal grains as the main staple of the diet. Raising the protein level and quality of the diet in Italy could be done readily by increasing the protein content of pasta with soy protein products. Professor Visco has set as his objective an increase of 10 percent in the soy protein content of pasta. He believes this amount of soy protein in pasta would provide all the essential amino acids necessary for good nutrition. The Institute has produced pasta containing 10 percent by weight of soy protein. Pasta containing the type of commercial soy protein used was unaltered in cooking quality, but had a slight gray

cast and slight change in flavor. The effect of lowering the content of soy protein on color and flavor of pasta is now being investigated. The effect of other sources of commercial soy protein on color and flavor will be studied, also. Professor Visco is interested in following up these studies by conducting nutritional investigations on groups of school children, using pasta fortified with soy protein.

In Japan, we are negotiating a grant with the Food Research Institute, in Tokyo, for research on dried tofu. Fresh tofu is the most important soybean food in Japan. On a dry basis, its protein content ranges from 50 to 60 percent, and fat content from 21 to 30 percent. It has a bland flavor. It is eaten as such usually with soy sauce. Slabs are deep-fat fried, also, forming an envelope which is stuffed with hot rice. Fresh tofu is made in thousands of small plants, many of them family operations. Fresh tofu has a relatively short storage life comparable to that of fresh milk. Dried tofu, which is a spongelike product, has come into production in recent years. It has a shelf life of 6 months or longer. However, the product is inferior to the fresh product in overall eating quality.

Under the grant to be carried out at the Food Research Institute there will be studied the varietal effect of soybeans, and variation of processing conditions on the physical characteristics and flavor of dried tofu. Fresh and dried tofu have promise in supplementing the diet in the protein deficient areas of the world.

Miso is another important soybean food used in Japan. It is produced by the fermentation of soybeans with *Aspergillus oryzae*. The most popular use of miso in Japan is in soup. Miso soup plays an important part in the standard Japanese breakfast. Because of uneven uptake of water, not all varieties of soybeans can be used, or only with difficulty, in the traditional Japanese process for making miso. Most Japanese and Chinese varieties of soybeans are better than most American varieties. In preliminary experiments conducted at the Northern Utilization Research and Development Division, in cooperation with two Japanese miso experts, it was found that dehulled soybeans or soybean grits absorbed water uniformly and yielded excellent miso. Now we are interested in following up these studies on a pilot-plant scale using different varieties of soybeans, and carrying out the fermentation under various Japanese environmental conditions. A grant on this project is being negotiated with the Central Miso Institute.

As it is produced at the present time, miso has a relatively high salt content. Salt is used in the process to control the microbiological population. Dr. György informs me that miso with a greatly reduced salt content might make it more suitable for feeding infants and young children. The development of procedures for producing miso containing very little salt might broaden its usefulness.

A related project on miso is under consideration in Israel. This is based upon producing a miso-type product from controlled amounts of oil ranging from none to that originally present in the bean. Japanese miso contains all the oil present in the bean.

We are negotiating one other project with the Food Research Institute in Tokyo. This project deals with the development of procedures for producing a yogurt-type product from soy milk, and obtaining information on the changes that occur in the soybean components in the transformation. It is planned to have cooperative investigations on the nutritional value of the fermented soy milk conducted at the Institute of Nutrition Research under Dr. Arimoto. Although soy milk has been used for many years in the Orient as an infant food, the expansion of its use has been very slow, particularly in the underdeveloped areas of the world. At times, difficulties have been encountered in its large-scale production due either to lack of technical knowledge or to inadequate control methods. Soy milk may cause diarrhea or flatulence in some infants.

It is possible that fermented soy milk may have advantages over soy milk. One potential advantage of fermented soy milk is that the acid may destroy undesirable microorganisms that too often occur under unsanitary conditions in underdeveloped areas of the world. The widespread use of yogurt in the original primitive areas of Northeastern Europe and Northern Asia may well have resulted from the comparatively greater safeness and stability of this product over milk. At the present time, 45 percent of all milk consumed in the USSR is in the form of yogurt, attesting its popularity and the fact that a taste for it can be acquired. Nutritional studies conducted in Europe have shown that yogurt is a highly nutritious product, and that digestibility is increased during the fermentation. Likewise, the fermentation of soy milk may lead to an improvement in its food value. At any rate, our hopes are high on this project.

Fermented proteinaceous foods are produced and used in Indonesia. Three types are tempeh, ontjom, and ragi. Tempeh was just discussed by Dr. Steinkraus. Onjom is made by fermentation of peanut press cake with molds, probably the genus Neurospora. It is a popular food in West Java. Ragi is produced by a yeast-mold fermentation of rice flour and sugar. Little is known about the microorganisms effecting this fermentation. Ragi is not served as food. It is used in recipes for the preparation of other foods.

More information on the microorganisms used in the fermentations to produce ontjom and ragi, and on the composition of these products, is needed. Similar types of products might be produced using other raw materials abundant in other underdeveloped countries. Knowledge on the quality of protein produced would be helpful in determining the usefulness of such products in upgrading the protein level of the diet.

A grant is being negotiated with the Bandung Institute of Technology, Indonesia, on the isolation of pure cultures of microorganisms present in tempeh, ontjom, ragi, and other Indonesian fermented foods produced by different manufacturers in different parts of Java, as well as other islands of Indonesia. Variations of species used by different manufacturers and in different regions for the same type of food fermentation will be investigated under this grant also. Studies will be made of the chemical changes and physical transformations brought about by the pure cultures. This will involve an investigation of the products produced in the fermentations including the proteins elaborated in all except the tempeh fermentation which already is receiving a great deal of attention. Pure cultures of the isolated microorganisms will be studied further and characterized at the Northern Utilization Research and Development Division.

A number of grants on soybean protein have been executed or are being negotiated with research institutes in Israel.

One of these deals with the effect of processing conditions on the yield and quality of isolated protein. This grant is being negotiated with Professor Zimmerman, of the Israel Institute of Technology. A great deal of work has been done in the United States and Japan on the commercialization of soy products. Large quantities are being produced, and some are being used for food purposes. However, there is need for more information on processing and drying of soy proteins, and the effect of processing conditions on flavor and nutritive value. This is the kind of research to be carried out in Dr. Zimmerman's laboratory. Also, he will study the flavor and acceptability of isolated soy protein when used in various Israeli-type foods. The effect of processing on the nutritive value of isolated soy protein will be determined by animal feeding tests.

Although much information has been obtained by Dr. Allan K. Smith and others in the United States on the physical and chemical properties of soy protein, little is known about the complexes of protein in the bean or in the meal. There has been neglected the problem of protein complexes in the native state or formed in soybean oil meal processing operations. Whether protein-phytate complexes exist in the bean or result from interaction during processing operations is unknown. No information is available as to whether nucleoproteins, lipoproteins, and mucoproteins exist in soybeans. We have no knowledge, either, as to the interaction with protein of pigments, metal ions, and carbohydrates during processing of the beans. However, these changes affect the color, flavor, and (in view of the sensitivity of lysine) the nutritive value of the protein. This problem on the chemical, physical, and biochemical properties of protein complexes in soybeans will be studied under a grant which is being negotiated with Dr. Katchalski at the Weizmann Institute of Science. Dr. Katchalski's team has a worldwide reputation for the fine work they have done on the structure and modification of

proteins. It is an ideal group to investigate this difficult and very important problem, the solution of which may lead to the enhancement of the food value of soy flour and soy protein.

A grant is being negotiated with Dr. Guggenheim, at Hebrew University, on the development and biological evaluation of protein-rich foods from vegetable sources. Various mixtures of cereals with combinations of soya, sesame, sunflower, and chick peas will be studied. The nutritive value of different combinations of proteins will be assessed on growing rats. In vitro methods of measuring the essential amino acids will be made, also, and compared with levels of amino acids present in the blood of the portal veins of rats following a protein meal. Nutritional evaluation of the protein mixtures on humans will be carried out at a later stage.

There has been a real need for the development of a rapid chemical method for measuring the biological value of proteins. Such a test would be very helpful in measuring change in nutritive value of proteins, including soy protein or flour, during processing and on storage. We are financing two studies on the development of such a method. One line of work is being carried out at the Israel Institute of Technology under Dr. Zimmerman, and the other at the University of Cambridge, England, under Dr. K. J. Carpenter.

We are financing three basic investigations on certain minor components of soybeans which may affect the nutritive value of soy products. One of these is a comprehensive study of the simple sugar and oligosaccharides in soybeans. This work is being done at the University of Caen, France. Another investigation deals with a detailed study of the polysaccharides of soybeans, and is being carried out at the University of Edinburgh, Scotland, under Professor Hirst. The third deals with the isolation and characterization of saponins in soybeans and various processed soy products. This study also will include the exploration of methods for inactivating saponins in the processing of soybeans. This work is being done by Professor Bondi, Hebrew University, Israel.

In this discussion I have summarized, briefly, the various lines of activity we are sponsoring abroad under Public Law 480 on soy protein and proteinaceous soy foods, and related investigations affecting the food value of soy products. It is hoped these investigations in countries where no work on soybeans has been done previously will stimulate additional research on soybeans, and lead to an increased recognition of the importance of soy products in the diet. It is believed these investigations will provide information that should be helpful in guiding efforts to upgrade the diet in protein deficient areas of the world.

Session IV

NUTRITIONAL AND BIOLOGICAL STUDIES

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THEORIES ON IMPROVING THE NUTRITIONAL VALUE OF SOYBEAN MEAL

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In 1917, Osborne and Mendel (1) reported the first controlled tests of feeding soybeans to rats. Their report showed that raw soybeans did not support normal growth, but cooked beans did. Osborne and Mendel attributed the improvement in nutritional value with cooking to improved digestibility of the protein and to improved palatability of the beans.

Osborne reported his work about 15 years before soybeans became a commercial crop in the United States and before the use of heat to improve their nutritional value became an important consideration. In the next 30 years, the soybean became more than a billion-dollar crop, and studies of the nutritional and biological properties of soybean meal exceeded all other areas of soybean research. Nevertheless, we are still puzzled about the growth and antigrowth factors in the soybean, and we cannot identify positively the components which are modified by moist heat to give a remarkable improvement in nutritive value of the beans. Trypsin inhibitors and hemagglutinin in the meal are usually credited with the poor nutritional value of the uncooked product, but a rigid evaluation of their effects on animal growth is not available. Let us review these factors and others which affect the nutritive value of raw soybean meal.

Two different viewpoints are expressed in the literature: One is that uncooked soybeans contain a toxic component which adversely affects animal growth. The other is that poor growth follows inability of the digestive system to liberate all the essential amino acids in the uncooked protein.

I shall not attempt to review all literature on the nutritive value of soybeans, but have selected references that illustrate the theories which have been advanced to explain the effect of moist heat on soybean meal.

Cystine-Methionine Availability Theory

Hayward, Steenbock, and Bohstedt (2) showed in 1936 that rats fed raw soybeans for 56 days gained only 19 grams, but when 0.3 percent cystine was added to the diet, the weight gain more than doubled (41 grams). When the rats were fed autoclaved soybean meal, the weight gain rose to 50 grams. Supplementing raw meal with cystine provided four-fifths of the growth obtained with moist heat.

Further studies on supplementation of raw and toasted meals with sulfur amino acids produced evidence that methionine was more effective than cystine and that methionine improved nutritional value almost as much as did a heat treatment. Along with these studies it was shown that cooking soybeans increased digestibility about 3 percent and biological value about 12 percent. Apparently improved digestibility alone does not explain the improvement induced with moist heat.

Later research demonstrated that methionine added to steamed soybean products gave a higher growth response than did the steaming alone, and it was further established that methionine is the limiting amino acid rather than cystine even though it is estimated that cystine can replace half of the methionine requirements. This early research work did not involve any toxicity effects, rather it led to the theory that cystine and methionine in raw soybean meal are not completely available to the animal and that denaturation with steam changed the structure of the protein to make these amino acids available. Such a theory was plausible because it was known that proteolytic action is usually increased by heat denaturation of proteins.

Amino-Acid Mutual Supplementation

The next theory also concerned the availability of essential amino acids and was based on the mutual supplementation principle.

The principle of mutual supplementation came partly from Elman's studies (3) of protein hydrolyzates. His work showed that a delay in adding a single essential amino acid to an otherwise adequate diet resulted in poor utilization of all other absorbed amino acids. This theory states that for good nutritional results all the essential amino acids must be available for absorption at approximately the same time and leads to the conclusion that they must be liberated during digestion *in vivo* at rates permitting mutual supplementation. This theory as applied to soybean meal was supported by the work of Melnick, Oser, and Weiss (4) and of Carroll, Hensley, and Graham (5). Using *in vitro* digestion studies, Melnick *et al.* reported that methionine was liberated more slowly from raw meal than it was from heat-processed meal. They concluded that the slow rate of liberation of methionine in the gastrointestinal tract, rather than the total methionine liberated, was responsible for the nutritional difference between raw and processed meals. The soybean trypsin inhibitor (SBTI), which had not been discovered at that time, probably explains these observations.

In other experiments Carroll *et al.* (5) fed rats both raw and heat-processed meals, sacrificed the animals, cut their digestive tracts into segments, and analyzed each segment for net absorption of nitrogen. They found that for heat-processed meal, all, or nearly all, of the nitrogen that is ultimately absorbed was absorbed during passage of the meal through the small intestine. However, for raw

meal much of the nitrogen was absorbed from the large intestine. They concluded that apparently the amino acids absorbed from the large intestines have little utility for growth, presumably as a result of bacterial activity. Their work substantiates the theory that incomplete absorption of essential amino acids accounts for the poor growth with raw soybean meal.

Trypsin Inhibitor and Hemagglutinin

A new theory quickly came into focus with the discovery of the trypsin inhibitor by Ham and Sandstedt (6) and Bowman (7) in 1944. This discovery of a substance that drastically retards the digestion of protein by trypsin *in vitro* seemed to explain satisfactorily the loss of sulfur amino acids in digestion and also to explain the low nutritional value of raw meal.

Since 1944 trypsin inhibitors have been found widely distributed in plant and animal life; for example, they occur in alfalfa, egg white, human blood serum, and colostrum, to name only a few sources. These many inhibitors differ in physical and chemical properties but all have the common property of inhibiting the activity of trypsin. Kunitz (8,9) applied his unusual talents to the isolation and crystallization of the first trypsin inhibitor from the soybean. More recently, work at the Northern Research Laboratory (10) has isolated a second SBTI. This second inhibitor has an antitryptic activity about 60 percent greater than the Kunitz inhibitor; however, its other physical and biological properties are yet to be published. Research on the biological properties of these proteins is very slow because of the difficulty of obtaining adequate quantities of the required purity. However, crude concentrated mixtures of these two inhibitors mixed with other proteins are easily secured and many experiments have been made with these impure protein mixtures. Although many feeding experiments with these crude preparations have shown a poor-to-excellent relationship between trypsin inhibitor activity and poor growth rate, experience has shown that conclusions from research with these crude preparations are not reliable.

The first experiments which seriously questioned the theory that SBTI retards growth were reported by Borchers and Ackerman (11). They studied the effect on animal growth rate of 17 legume seeds before and after autoclaving. Eleven of these seeds gave a positive test for antitryptic activity. Autoclaving improved the nutritional value of 5 of the 11 seeds, but did not improve the other 6. Borchers and Ackerman's results indicate that trypsin inhibitor activity per se does not retard animal growth.

Liener (12) soon brought out additional information on the biological properties of SBTI. Because of the limited amounts available he used an intraperitoneal injection technique to test toxicity. He tested both crude and crystalline inhibitor on rats and found that

although the crude preparation was toxic, the crystalline inhibitor injected at an equally high level of activity failed to show toxicity. These results further questioned the toxicity of SBTI.

Continuing his studies Liener (13) was able to isolate and purify another protein from the crude inhibitor concentrate. He found this protein had the property of agglutinating red blood cells and at first he called it soyin but later changed its name to hemagglutinin. He proceeded to isolate and purify the hemagglutinin and when injected in rats it was found to have toxic properties.

Limited oral-feeding tests of the hemagglutinin with chicks also indicated it to be a mild growth inhibitor. However, the conclusion that hemagglutinin is a growth inhibitor is somewhat clouded because it also appears to be an appetite depressant and the poor growth in Liener's feeding tests can be interpreted as due to the low rate of food intake rather than to toxicity.

Further work in this area has been delayed because of the high cost of preparing sufficient quantities of purified hemagglutinin for animal testing.

Another phase of the effect of trypsin inhibitor on digestion has been reported by Chernick, Lepkovsky, and Chaikoff (14) and by Lyman and Lepkovsky (15). Using rats these workers studied the effect of SBTI on the size of the pancreas and its secretion of enzymes. They found that feeding either crude SBTI or raw meal enlarged the pancreas and greatly stimulated its activity. They measured the activity of trypsin, pepsin, lipases, and amylases in the gut after feeding diets containing raw and heat-processed meal. For a very brief period after intake started the activity of the trypsin in the gut was reduced, but this low tryptic activity was soon followed by increased secretion of enzymes so that after 6 hours, the secretion of trypsin was three times greater than normal. The lipases and amylases were three to four times more than normal, but the pepsin was unaffected. Also, they determined the concentrations of these enzymes in the pancreas itself and found them to be substantially reduced within a few hours after feeding either raw meal or crude trypsin inhibitor. They report that "It would seem unlikely that in the rat growth inhibition could result from insufficient intestinal proteolysis. The short period when proteolysis might not be optimum would be quickly counteracted by the interval when excessive trypsin activity is present." Thus we now have a complete reversal of the theory concerning the effect of trypsin inhibitor in animal feeding.

Lyman (16) also measured the amount of nitrogen in the intestines of rats after they were fed both raw and processed meals. He found that less nitrogen was ingested by rats fed raw meal and that the raw meal nitrogen was not as well utilized as nitrogen from processed meal. Lyman concluded from these studies that

"If one accepts the views that soybean trypsin inhibitor plays an important part in growth depression of rats, it would appear that the inhibiting action may be exerted through a loss of essential amino acids from endogenous sources rather than depression of normal intestinal protein hydrolysis." To say it another way, there may be sufficient loss of protein in the feces from the enzymes secreted by the pancreas to reduce the nutritive value of the protein.

In collaboration with the Western Division we have made two preliminary feeding tests with rats with a purified trypsin inhibitor of the Kunitz type. Our tests were made by adding the purified inhibitor to a casein diet. The first feeding test was with 0.3 percent inhibitor based on the weight of a diet containing 10 percent casein, and the second test was with 0.6 percent inhibitor based on a 14-percent casein diet. The diet with the lower levels of both inhibitor and casein depressed the appetite and retarded growth, whereas in the test at the higher levels of inhibitor and protein, the food intake and growth rate were normal. Pancreas enlargement was observed in both tests.

On first consideration these tests might appear to be contradictory. However they are consistent with recent feeding tests of Borchers and Ackerman (11) using various levels of raw meal in the diet. Their feeding tests included raw and heat-processed meals with and without added methionine at levels ranging from 10 to 40 percent of the diet. With the raw meal, as well as with autoclaved meal, there was an increase in growth rate with increasing levels of meal. The grams-per-day gain with 40-percent raw meal plus methionine was almost as much as on autoclaved meal plus methionine. These data fail to support the hypothesis of a toxic factor in raw soybeans. They are consistent with our SBTI feeding tests in that the effect of the inhibitor on growth appears to disappear at high levels of protein intake although in these high-protein diets the protein efficiency ratio is low.

Experiments with laying hens contribute further information to this problem. Fisher et al. (17) fed laying hens raw and processed meal at two different levels with and without added methionine plus vitamin B_{12} for a 28-day period. Protein was at a 15-percent level and they added 0.3 percent methionine. Egg production on raw meal was 21.8, 17.9, and 18.0 (avg. 19.2) percent, and with heat processed meal it was 23.2, 17.2, and 18.9 (avg. 19.8) percent. Under these conditions the raw meal was as effective for laying hens as was the processed meal, and no toxic effects were apparent. However, in another series of tests at a protein level of 12.2 percent, the processed meal gave good egg production but the raw meal did not. These experiments showed also that utilization of sulfur amino acids from raw meal was inferior to that of the heat-processed meal.

In another experiment, Borchers (18) reported that poor growth of raw meal can be entirely overcome by supplementation with the four

amino acids--L-tyrosine, DL-methionine, DL-threonine, and valine. He stated that when any one of these four amino acids was omitted, growth equivalent to the processed meal was not attained. Since Borchers has not yet published his experimental data, this work was repeated by Booth (19). He also found that addition of the four amino acids to the raw soybean meal diet corrected for poor growth and reduced feed efficiency. However, the diet did not prevent pancreatic hypertrophy.

Summary

Feeding tests that show increasing growth rate with increasing levels of raw soybean meal in the diet fail to show the expected toxic effect. Results reported in the literature and obtained by feeding different levels of raw meal may have led in some experiments to misinterpretation of the result and to some of the apparent contradictions. Another source of error may have been the use of crude trypsin inhibitor preparations to relate the trypsin inhibitor activity to growth studies; in some instances the effect of hemagglutinin may have been mistakenly attributed to the soybean trypsin inhibitor (SBTI).

However, there have been some solid accomplishments; experiments have repeatedly demonstrated that 80 percent or more of the protein efficiency ratio of raw and heat-processed meal can be made up by supplementation with methionine and the remaining difference by additional supplementation with valine, tyrosine, and threonine. These and other experiments support the theory that poor growth of raw meal is mostly a lack of absorption of one or more of the amino acids rather than the presence of a toxic component.

Stimulation of the pancreas by raw meal shows there is no lack of enzymes in the gut for protein digestion. Rather, as Lyman has stated, there is an undetermined loss of endogenous nitrogen in the feces through excessive secretion of enzymes.

Since soybean protein has a substantial shortage of methionine for proper balance with the other essential amino acids, then further small losses would have an increasingly large depressing effect on growth. However, these conclusions fail to account for the effect of hemagglutinin on growth and further work on its biological properties is necessary for evaluating completely its effect in animal feeds.

A measure of the loss of essential amino acid in the feces through stimulation of the pancreas would be a valuable contribution towards explaining the effect of SBTI in animal feeding tests. Fortunately the activity of SBTI and hemagglutinin is easily destroyed by moist heat and, so far as we can determine, they are not concerned in the nutritive value of processed soybean meal.

Discussion: The question was raised as to the presence of an antithiamine factor and the effects of saponins. Demonstration of an antithiamine factor is dependent on the method of assay to show a loss. Saponins in forage have been shown to be toxic. Saponins are precipitated by the cholesterol present in soybeans so there is no apparent effect. The level of feeding, however, affects results.

Goitrogenic effects have been reported, but appear to be controlled by adding small amounts of iodine to the diet and are not significant in feeding.

Dr. Barnes commented that information on the trypsin inhibitors is most exciting. In feeding more and more raw soybean meal you can still not get growth equivalent to properly heated soybean meal and can eventually get a depressing effect. Differential endogenous excretion of nitrogen needs clarification. There is a decrease in absorbability of nitrogen and of methionine. The work of Borchers showed that a mixture of amino acids increased growth rate of raw soybean meal and also increased growth from feeding heated soybean meal. We have never equalled growth rate of autoclaved soybean meal by supplementing raw soybean meal.

Dr. Hand wondered if there were any other reactions beside rate of growth which could be commented upon. There are some but no experimental evidence on which to base comments.

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PROTEIN EFFICIENCY STUDIES ON SOYBEAN MEAL AND ITS FRACTIONS

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After many investigations, beginning with Osborne and Mendel in 1917 (8), considerable uncertainty still exists concerning the nature of the factors in raw soybean meal that inhibit growth of monogastric animals. A number of physiologically active substances have been reported in raw meal and reviewed by Liener (7). In more recent experiments, Booth et al. (1) reported that when raw meal was fed to rats as a sole source of dietary protein, the only adverse effects noted were (a) poor growth, (b) reduced food efficiency, and (c) pancreatic hypertrophy.

With soybeans becoming an important source of protein for human food, the peculiarities related to nutritional value of raw meal need explanation. The investigations reported here are a determination of the effect of heat treatment of raw meal and long-term feeding of raw meal on rat growth and pancreas. The nutritional quality of raw and toasted meal fractions and of isolated proteins was also investigated.

Experimental Results

Weanling male albino rats, separated into groups of five according to weight, were fed diets ad libitum. Rat tests were made in collaboration with the Western Division, according to methods previously described (1). The casein control diet was formulated as indicated in Table 1. Experimental diets were substituted for casein, cerelose, and powdered cellulose in amounts necessary to maintain equal protein levels.

Table 1.--Composition of basal diet

Ingredient	Percent of diet
Cerelose	50.7
Casein[1/]	17.3
Corn starch	20.0
Salts (USP, XIV)	4.0
Vitamin mix, complete	2.0
Powdered cellulose	2.0
Soybean oil	4.0

1/ N x 6.25 = 14% protein.

Klose, Hill, and Febold (4) showed that moist heat greatly increases the protein efficiency ratio (PER) of raw soybean meal and that dry heat does not. Their data were used to plot Curves A and B of Figure 1. Dry heat (Curve A) had no effect on PER. After raw meal was steamed in an autoclave at atmospheric pressure, the PER (Curve B) increased rapidly to a maximum value after 30 minutes toasting, followed by a gradual decrease. In our re-evaluation of this effect, defatted soybean meals containing 5 and 19 percent moisture before autoclaving were heated with steam for varying times at atmospheric pressure. After raw meal containing 5 percent moisture was autoclaved, its PER increased from 1.25 to 1.85 within 15 minutes, but no further change occurred even up to 75 minutes of heating (Curve C). A maximum PER of about 2.04 was obtained after meals containing 19 percent moisture were autoclaved for 15 minutes (Curve D), and little or no change occurred after 2 hours of autoclaving. The differences between Curves C and D were not statistically significant; however, PER for autoclaved, low-moisture meals varied considerably. This variability has been attributed to a case-hardening effect that retards rapid steam penetration. The beneficial effect of steam treatment is consistent with the theory that proteins and enzymes are denatured and inactivated with moist heat.

The high PER obtained with meals containing high moisture (Curve D) indicates that growth inhibitors are readily destroyed by very mild heat treatment and that further heating under these conditions does not produce destructive changes. Furthermore, pancreatic hypertrophy no longer occurs in rats fed soybean meal autoclaved for as little as 15 minutes. The stability of soybean proteins to heat helps to explain the very close agreement in PER obtained by UNICEF for several commercial soyflours, which have been manufactured under widely different conditions (6).

Also studied was the question of whether growth inhibition can be reversed by switching rats from a raw meal as a sole source of dietary protein to a casein ration (Table 2). Weanling female rats after 35 days on a raw meal diet weighed 50 grams less than those on casein, and pancreas weights were nearly twice as large. When rats on a raw meal diet were switched to casein, final body weights were 20 grams higher than for those fed casein for the entire 192 days, and there was no pancreas enlargement. Within this period, growth inhibition and pancreatic hypertrophy were reversible. After 192 days the difference between body weight of rats fed raw meal and casein was only 26 grams. Pancreas enlargement in rats fed raw meal for 35 and 192 days was the same.

In processing soybeans into protein concentrates for food, several fractions are obtained. Their method of preparation are given in Figure 2. All operations were made at room temperature. The residue and acid-precipitated protein fractions are commercial products. Acid-precipitated protein is commonly referred to as

Table 2.--Reversal of growth inhibition of rats fed raw soybean meal

Diet	Dietary constituent	Days	Average body weight		Difference in body weight	Pancreas weight
			Start	Final		
			Grams	Grams	Grams	Grams/100 grams of body weight
1	14% Casein	38	32.8	129.4	--	0.34 ± 0.03
2	Raw meal	38	32.8	80.8	(-) 48.6	0.65 ± 0.03
3	14% Casein	192	32.2	209.8	--	0.35 ± 0.04
4	Raw meal	192[1]	32.6	229.7	(+) 20.1	0.41 ± 0.05
5	Raw meal	192	33.3	184.2	(-) 25.6	0.61 ± 0.02

1/ Group switched to the casein diet after 35 days.

isolated soybean protein. Food-grade and industrial-grade proteins are manufactured. The latter has been chemically modified for non-food uses; nevertheless, it has been used in some nutritional studies. Another commercial product, commonly referred to as 70-percent protein concentrate, is obtained by extracting the meal at pH 4.4. This concentrate contains both the residue and acid-precipitated protein fractions.

The whey solution currently is disposed of as waste. In the laboratory it is converted into either a whey solids or isolated whey protein fraction. The whey proteins are of particular interest to us because many of the biologically active proteins of the soybean are concentrated in whey, and research on this fraction has therefore become part of our basic studies on soybean proteins.

Figure 3 shows the gradient elution diagram of whey proteins fractionated on DEAE-cellulose, an anion exchange adsorbent. At least 13 distinct protein peaks designated A to M in the order of their elution were obtained (9). Previous electrophoretic studies disclosed the presence of five components, whereas only two components were found in ultracentrifugation patterns. Using a modified chromatographic procedure, Rackis et al. (11) isolated two highly purified trypsin inhibitors from whey. One inhibitor is identical to Kunitz' crystalline trypsin inhibitor (5). The other has been characterized for the first time in our laboratory (11) and is nearly 60 percent more active on an equal weight basis. Kunitz' trypsin inhibitor appears to be directly involved with growth inhibition and pancreatic hypertrophy (3). At present, only Kunitz' inhibitor has been fed in an animal ration, and its effects do not account for all of the physiological effects associated with raw meal, which indicates that the new trypsin inhibitor may also be involved (3).

Except for limited nutritional data on acid-precipitated protein, there is no published information on the other fractions. PER and weight gains of rats fed residue and acid-precipitated protein prepared in the laboratory or commercially are given in Table 3. Toasted refers to those fractions that were autoclaved with steam for 30 minutes at atmospheric pressure and 100° C.

Raw residue, accounting for 50 percent of protein in the diet, when fed to rats, resulted in a 12-percent loss in weight and in a significantly reduced PER ($P < 0.01$) as compared to casein diets. Autoclaving the residue fraction resulted in an increased weight gain and PER. Although weight gains for the toasted residue diet were comparable to casein, PER was much lower. We have attributed this difference to a cystine-plus-methionine deficiency because of a lower protein score for the residue. The protein scores were determined by the system developed by FAO (2) and are based on the amino acid data of Rackis et al. (10).

Table 3.--PER and protein score of casein and soybean meal residue and acid-precipitated protein fractions

Diet	Dietary constituent	Average body weight Start	Gain ± S.E., 35 days	PER	Protein score[1]
		Grams	Grams		
6	14% Casein	49.8	144.2 ± 3.11	2.29	80
7	Raw residue	49.8	126.8 ± 9.34	1.54 **	54
8	Toasted residue	49.8	151.2 ± 5.81	2.04 *	54
9	14% Casein acid-precipitated protein	40.0	154.6 ± 3.98	2.25	80
10	A[2]	40.0	134.2 ± 6.13 *	1.82 **	--
11	B	40.0	131.6 ± 5.04 **	1.65 **	--
12	C	40.0	128.2 ± 3.06 **	1.76 **	--
13	D (raw)	40.0	109.6 ± 2.84 **	1.40 **	54
14	D (toasted)	49.8	114.8 ± 5.42 **	1.63 **	54
15	Toasted soybean meal	40.0	162.2 ± 4.67	2.01 *	73
16	14% Casein	42.0	135.2 ± 12.60[3]	1.93	80
17	Toasted acid-precipitated protein	42.0	122.4 ± 9.48[3]	1.72 **	54
18	Toasted acid-precipitated protein plus 0.3% methionine	42.0	148.0 ± 6.81	2.07 *	--

1/ Cystine plus methionine are the first limiting amino acids.

2/ Acid-precipitated proteins A, B, and C are commercial products, designated food-grade; D was prepared in the laboratory.

3/ A 38-day period for diets 16-17.

* $P < 0.05$

** $P < 0.01$

Weight gains and PER for rats fed laboratory and commercial acid-precipitated proteins, as the sole source of dietary protein, were significantly lower compared to those for rats fed either toasted soybean meal or casein. A comparison of diets 13 and 14 in Table 3 shows that weight gain and PER increased only slightly after autoclaving meal for 30 minutes at atmospheric pressure. There are small differences in PER between commercial acid-precipitated proteins, which probably reflects differences in manufacture.

Acid-precipitated protein also has a low protein score (10); cystine plus methionine are the first limiting amino acids. The effects of methionine supplementation on PER are shown with diets 5-7; weight gains are now comparable to casein, and the PER is significantly higher ($P<0.05$). These results are consistent with the amino acid composition of the acid-precipitated protein.

Raw whey solids, in replacing 20 percent of the casein and accounting for 13 percent of the diet, resulted in marked growth inhibition of rats (Table 4). Growth inhibition and reduced PER were equal to a raw meal diet containing the same amount of whey solids. Therefore, the factors in the whey can account for all of the adverse dietary effects associated with raw meal; however, toasting whey solids for as long as 60 minutes had very little effect on their nutritive value, whereas soybean meal toasted for as little as 15 minutes has a nutritive value nearly comparable to that of casein. The different response of the whey solids to heat presents a situation wherein the parts do not behave like the whole. To a limited extent the residue also exhibits more heat stability.

Raw isolated proteins fed at the 5-percent level in a casein diet also markedly inhibited rat growth and accounted for part of the growth inhibitory properties of whey solids (Table 4). Toasted isolated proteins, on the other hand, resulted in better growth and higher PER than casein. The protein score for whey proteins (10) is slightly higher than for casein, which accounts for the high biological value of whey proteins as measured by rat growth and PER values.

Summary

Significantly reduced weight gains and protein efficiency ratio (PER) for rats fed raw soybean meal as a sole source of protein were increased to values nearly comparable to casein diets, after the meal was autoclaved with steam for 15 minutes at atmospheric pressure. The pancreas-stimulating factor is also destroyed under these conditions. Maximum PER was obtained with meals, containing nearly 20 percent moisture initially, that were autoclaved for as little as 15 minutes and the meals for as long as 2 hours.

Table 4.--PER and protein score of casein and soybean meal, whey solids and isolated whey protein fractions

Diet	Dietary constituent	Average body weight		PER	Protein score[1]
		Start	Gain ± S.E.		
		Grams	Grams		
19	12% Casein	68.5[2]	161.6 ± 6.06	2.00	--
20	Raw whey solids	68.5	108.4 ± 2.77 **	1.22 **	--
21	Raw soybean meal	68.5	109.3 ± 2.96 **	1.25 **	--
22	14% Casein	42.0[3]	135.2 ± 12.60	1.93	80
23	Raw whey proteins	42.0	77.2 ± 4.88 **	1.57 **	87
24	Toasted whey proteins	42.0	145.5 ± 16.81	2.14 **	87

1 Limiting amino acids are cystine plus methionine.

2 A 51-day period.

3 A 38-day period.

* $P < 0.05$
** $P < 0.01$

Raw residue, acid-precipitated protein, whey solids, and isolated whey protein fractions resulted in poor growth and greatly reduced PER. Autoclaving for 30 minutes at atmospheric pressure had much beneficial effect on the residue and isolated whey protein fractions, and weight gains and PER of the acid-precipitated protein diets were increased slightly. Autoclaving for 60 minutes had no effect on weight gains and PER for rats fed whey solids.

Since toasting had only a little effect on the PER of the acid-precipitated protein and methionine supplementation had a great effect, it is unlikely that the lower biological value of the fraction, as compared with that of raw meal, is due to the presence of growth inhibitors. On the other hand, poor growth and reduced PER of the isolated whey proteins appear to be due to the presence of heat-labile growth inhibitors.

Raw whey solids, fed at a level corresponding to the amount found in raw soybean meal, accounted for all of the growth inhibitory properties of raw meal and similarly reduced PER. It was expected that feeding raw meal would result in maximum growth inhibition and minimum PER since the raw residue acid-precipitated proteins and whey protein fractions also reduced growth and PER. It would appear, therefore, that an interrelationship between factors determines the biological value of soybean meal. The peculiarities associated with feeding raw meal to monogastric animals are probably derived from an interaction between substances in soybean meal.

Although body weights of rats fed raw meal for 35 days were about 50 grams less than for casein diets, growth inhibition can be reversed by switching the rats to casein diets. Pancreatic hypertrophy is also reversible. These results indicate that growth inhibition and reduced PER of raw meal diets do not produce toxic effects in rats.

Discussion: The comment was made that isolated soy protein is for the rich, not the poor. A small amount of methionine supplement would probably be sufficient in a human diet based on soybean protein. There was a further comment that there is some confusion on the nutritive value of isolated protein, since its PER is not as high as for toasted soybean meal.

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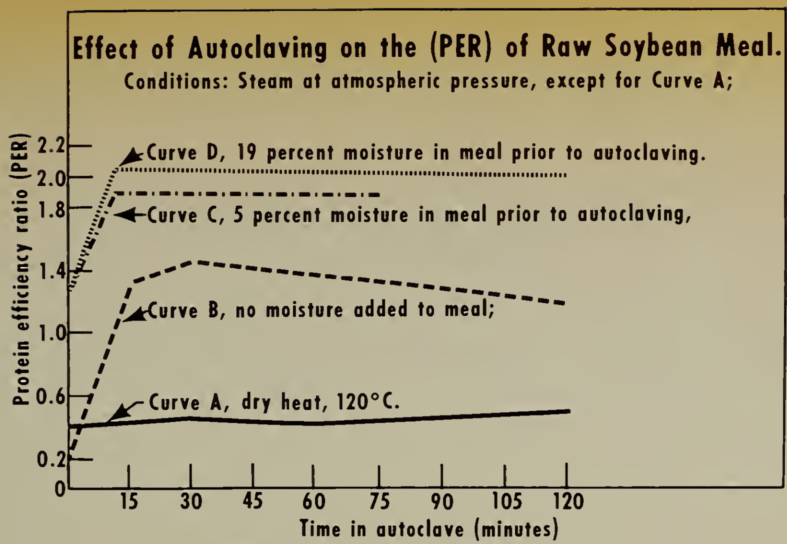


Data for curves A and B were taken from Klose *et. al.* (3).

Figure 1.

Preparation of Soybean Meal Fractions

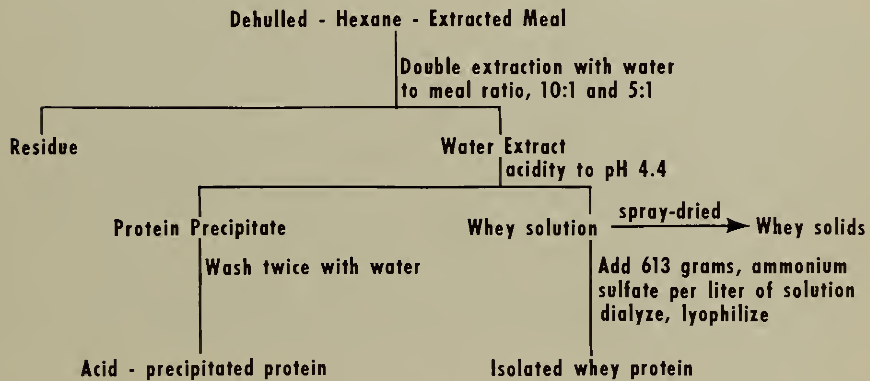
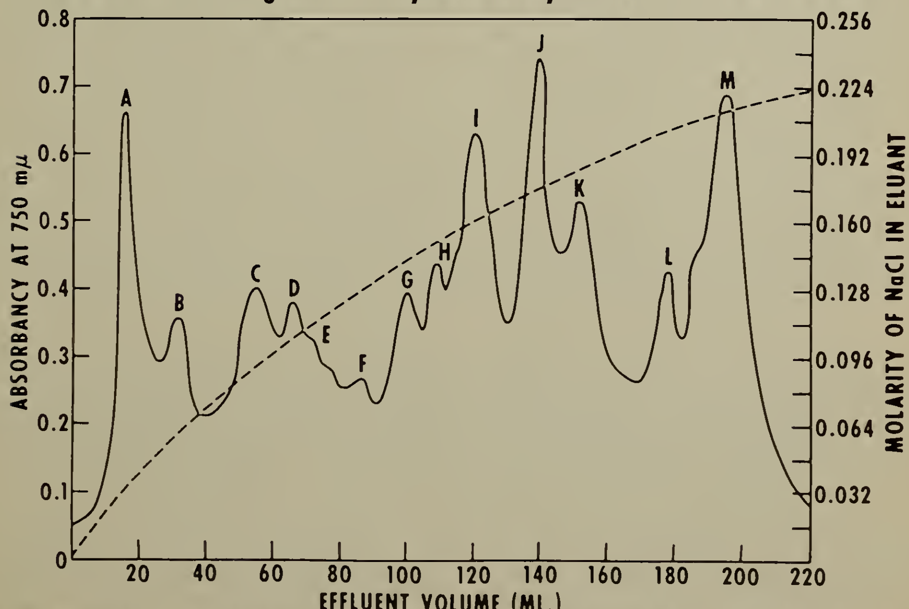


Figure 2.

Gradient Elution Diagrams of Soybean Whey Proteins on DEAE Cellulose.



Broken line and scale at right represent sodium chloride concentration of eluant. Other conditions, see ref. 9.

Figure 3.

PHYSIOLOGICAL EFFECTS OF FEEDING SOYBEAN MEAL AND ITS FRACTIONS

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The raw soybean, when ingested by animals, is truly a gold mine of biologically active substances. A listing of these includes trypsin inhibitors (pancreas stimulants), hemagglutinin (soyin) activity, estrogenic factors (isoflavones), goitrogenic factor, zinc nonavailability factor, saponins, antivitamin activity, and growth factors. From a practical viewpoint, none of these substances in commercial soybean oil or meal appear to be exerting harmful effects. However, we are convinced that a better understanding of the chemical nature and physiological activity of these factors should help to determine if certain beneficial effects might be realized.

Starting at the bottom of the list, the evidence for growth-promoting effects rests largely on chick-growth studies. One growth factor has been located in the water-soluble fraction of soybean meal and a second growth stimulant has been demonstrated in soybean oil and other vegetable oils. The active substance in soybean oil may be linoleic acid, since this essential fatty acid can elicit the same kick in growth as the vegetable oils when fed to chicks. Attempts to identify the water-soluble factor are still in progress; both organic and inorganic factors appear to be involved (1).

Regarding antivitamin factors, thiamine and vitamin A specifically are implicated. In view of the fact that there has been very little in the recent scientific literature to support the earlier observations, it is concluded that factors in soybeans that interfere with the utilization of thiamine and vitamin A are very weakly active or nonexistent. While on the subject of vitamins, it is pertinent to mention the nutritional value of soybeans as a dietary source of thiamine and riboflavin. Recently, while participating as a member of the nutrition survey team in South Viet Nam, we observed a considerable incidence of thiamine and riboflavin deficiencies in this rice-eating population. One of our recommendations to correct the lack of thiamine and riboflavin was to increase the consumption of soybeans (Table 1).

The saponins in soybeans and other plants including alfalfa have been shown to inhibit chick growth. Saponins have also been implicated in ruminant bloat. In view of the current interest in the

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Table 1.--Riboflavin and thiamine content of foods

	Mg./100 g. edible portion (not cooked)[1]	
	Riboflavin	Thiamine
Soybeans	0.31	1.07
Tamarind	.14	.34
Chinese cabbage	.17	.06
Cress	.16	.08
Garden peas	.16	.34
Pork, lean	.16	.69
Duck	.20	.08
Eel	.28	.21

1/ Composition of Foods Used in Far Eastern Countries, Agriculture Handbook No. 34 (16).

problem of atherosclerosis it is interesting that saponins have the ability to combine with cholesterol; in fact, the saponins can be isolated and purified by formation of saponin-cholesterol combination products from which the saponins can later be regenerated. The possibility exists that the absorption of dietary cholesterol in our diets is reduced by the ingestion of saponins in the foods we eat.

The factor in soybeans that limits the availability or utilizability of dietary zinc for animals, such as swine and chicks, is an interesting one. Seventy percent of the phosphorus in soybean meal is in the form of phytin. In the extraction of protein from soybean meal, Smith and Rackis here at NU have done an excellent piece of work in demonstrating that phytic acid forms a complex with the isolated soy-protein (2). It is this protein-phytic acid complex that combines with or ties up zinc to make it unavailable when ingested by the animal (3). Uncombined phytic acid on the other hand has no effect on the availability of zinc (Table 2). The importance of having an adequate content of zinc in diets containing soybean protein is emphasized.

Various investigators have reported that soybeans contain a goitrogenic agent that increases the iodine requirement of chicks and rats. This slight goitrogenic property of raw and heated soybeans is not of practical importance in animal nutrition, since small amounts of iodine can effectively prevent the resulting thyroid enlargement (4).

Table 2.--Availability of zinc for chick growth

Dietary supplement	Weight at 4 weeks
	Grams
Soy-protein basal	162
Above + zinc (15 p.p.m.)	382
Above + zinc (55 p.p.m.)	473
Soy-protein-phytic acid complex	97
Above + zinc (15 p.p.m.)	227
Casein-gelatin basal	447
Above + calcium phytate	438

B. L. O'Dell and J. E. Savage, Proc. Soc. Exp. Biol. and Med. 103, 304 (1960).

Concerning estrogenic substances in soybeans, two isoflavones, genistin and daidzein, have been isolated and identified in the meal (5). On a weight basis the isoflavones are only about one fifty-thousandth as active as the synthetic estrogen diethylstilbestrol (Table 3),

Table 3.--Estrogenic activity of some isoflavone derivatives

No. of mice	Treatment	Avg. uterine wt.
		Mg.
6	Normal control	6.4 ± 0.8
6	10 mg. biochanin A	20.9 ± 3.1
5	10 mg. daidzein	26.6 ± 4.1
6	10 mg. formonetin	8.9 ± 1.2
5	10 mg. genistein	19.3 ± 1.3
6	0.1 µg. stilbestrol	15.7 ± 1.5

E. Cheng *et al*., Science 120, 575 (1954).

which is currently being used to increase the growth rate and food efficiency of 80 percent of the beef cattle in the United States. It is also interesting that there is sufficient genistin in the subterranean clover of Australia to cause sterility or infertility in sheep when eaten in large amounts. A weakly positive estrogen-like action has also been reported in soybean oil and other vegetable oils (6). This is based on the increased uterine weight

response of immature female mice when these vegetable oils, including soy, corn, rice, and wheat germ, are fed (Table 4). In view of the current use of estrogen therapy in human males to reduce blood cholesterol levels, the natural occurrence of estrogens in soybeans has some interesting implications.

Table 4.--Mouse uterine weight response to various oils

Supplement	Level fed	Mean uterine wt.
	%	Mg.
None (control diet)	--	10
Cottonseed oil (refined)	10	16
Mineral oil	10	8
Castor oil	10	9
Wheat germ oil	10	15
Peanut oil	10	16
Soybean oil	10	17
Rice bran oil	10	22
Corn oil	10	17

The hemagglutinin activity in soybeans has been discussed by Dr. Smith. We have been unable to detect evidence of rat growth inhibition by this factor in rats with our experimental conditions.

As stated earlier by Dr. Smith, the discovery of the presence of trypsin inhibitors in soybeans and other legumes and the ability of concentrates of these factors to inhibit growth in rats and chicks have led to the hypothesis that there is an interference in the normal enzymatic protein hydrolysis in the intestinal tract. However, experiments by Klose *et al.* (7) with hydrolyzed proteins have given results that are contradictory to this hypothesis (Table 5). Our contribution to this problem is the inclusion of pancreas weight data (Table 6) which suggests a new working hypothesis in order to explain the growth-inhibiting effects of raw soybeans (8). Since pancreas enlargement persists, even when good growth is brought about by the addition of four amino acids (methionine, tyrosine, valine, and arginine) to a diet containing raw soybean meal (9), it follows that pancreas stimulation could be the primary cause of poor growth and that the added amino acids simply replace the fecal loss of these same limiting amino acids in the pancreatic secretions. After all, these pancreatic secretions are enzymes which are proteins and which therefore contain amino acids. Quite independently, the work that Lyman (10) has reported supports this fecal nitrogen loss concept by showing that there is an excess of pancreatic

secretions, including trypsin, in the intestinal tract of rats ingesting either raw soybeans or crude trypsin-inhibitor and further that there is pancreatic enzyme activity in the feces.

Table 5.--Growth inhibition produced by lima bean protein fractions in rats on casein hydrolyzate diets

Diet supplements	Feed consumption	Weight gain
	G./rat/day	G./rat/day
Casein hydrolyzate	8.5	3.3
Same + raw lima bean extract	7.2	1.7
Same + heated lima bean extract	8.0	3.4
Commercial casein	9.0	3.5
Same + raw lima bean extract	7.3	1.1

A. A. Klose *et al.*, Science 108, 88 (1948).

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Table 6.--Effects of raw and heated soybean meal and amino acids on growth, pancreas weights and food efficiency of rats

Dietary protein	Final body wt.	Pancreas wt.	Food efficiency
	G.*	G./100 g. body wt.*	Wt. gain/g. food*
(1) Casein	147.40 ± 3.88	0.56 ± 0.04	0.31 ± 0.01
(2) Raw soybean meal	89.00 ± 3.54‡	.85 ± .08‡	.19 ± .007‡
(3) *Idem* + amino acids	142.40 ± 7.11	.93 ± .06	.28 ± .01
(4) Heated soybean meal	148.40 ± 3.27	.50 ± .02	.29 ± .006

* ± S.E.

‡ P = < 0.01

According to our pathologist, the acinar cells of the pancreas are stimulated when raw soybean meal is fed. It is the acinar cells which are responsible for the secretion of digestive enzymes including pancreatic amylase, lipase, and trypsin. The pancreatic islets which secrete insulin are not affected. Except for the pancreatic

hypertrophy, no other pathological effects were detected in the tissues of animals autopsied after ingestion of raw soybean meal for 5 to 8 weeks. This was also true when either adult or weanling rats received raw soybean meal for 200 days. One of the most serious chronic diseases of childhood is cystic fibrosis of the pancreas (11). Pancreatic insufficiency or the absence of pancreatic trypsin, lipase, and amylase leads to poor digestion and absorption of food. Judging by the number of requests we have received from clinicians for reprints of our report on the rat pancreas-stimulating factor in raw soybeans (8), it looks hopeful that trypsin-inhibitor concentrates may be tried experimentally for the treatment of cystic fibrosis.

A somewhat different problem presents itself when the soybean meal is fractionated into various parts and these various fractions are evaluated biologically. The acid-precipitated protein from soybeans is taken to illustrate this point. Unheated, this protein fraction does not support good growth, yet the pancreas-stimulating activity is relatively weak. The situation is clarified somewhat when this same protein is heated or toasted and then fed to rats. Pancreas stimulation is now eliminated, yet growth continues to be depressed (Table 7). At least two new variables may now be entering the picture, variables that were not involved when the entire meal was fed. In the first place, one or more amino acids in the isolated protein could now be more critical so that elimination of amino acid losses via the pancreas fails to correct the imbalance. A second factor is the distinct possibility of a zinc deficiency, since the unbound zinc in soybean meal would not be expected to reside in the isolated protein fraction. A combination of these two effects, as well as other possibilities, must also be considered.

Table 7.--Isolated soybean protein studies in rats

Diet	Wt. gain in 35 days	Pancreas wt.	Food efficiency
		G./100 g. body wt.	Wt. gain/g. food
14% Casein control	115	0.47	0.31
14% Isolated raw soy protein	69	.56	.20
14% Casein control	94	.43	.32
14% Isolated heated soy protein	65	.45	.23

In summary, it is obvious that more research work must be accomplished before we can answer all questions that arise. However, the end result will inevitably be reached, in that the maximum utilization of soybeans as foods and feeds will be realized.

Discussion: Dr. Gyorgy commented briefly on tempeh antioxidants. The antioxidant is genistin and the antioxidant activity in soybeans is 400-800; in tempeh, 1,700; and in genistin, 3,600.

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NUTRITIONAL STUDIES RELATING TO DEVELOPMENT OF SOY CONTAINING FOODS

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The interest and research in soybeans and soybean proteins at our Research Center goes back over many years, and encompasses the work of many individuals. The three primary areas of interest in soybean-containing foods in the past 10 years includes (a) the use of soybean feeding formulas for the infant, (b) the use of soybean meal to improve the quality of the protein in precooked infant cereals, and (c) the use of the soybean to help supply a high level of good quality protein in the formulation of special nutritional products. Much of the work has been concentrated on the processing of soybean meals and of soybean-containing products with a view toward producing products of the highest nutritional quality possible. Most of the data which will be presented in this report are taken from nutritional studies carried out in conjunction with the product development studies.

Some of the data are taken from studies carried out several years ago by Dr. Warren M. Cox, Jr. and Arthur J. Mueller and the remainder, from more recent studies in our department, carried out by Dr. A. B. Morrison, Dr. J. J. Barboriak, and others.

Soybean Formula Products

As an introduction to the earlier studies on developing soybean milks for infant feeding (Figure 1) shows the weight gains of rats fed diets containing various levels of protein as a casein-lactalbumin mixture or as soybean meal for 6 weeks. At all levels of protein in the diet, the casein-lactalbumin mixture gave a somewhat better growth rate than did the soybean meal, but the animals on the soybean meal diet did quite well. The animals on the 7.5-percent diets were kept on these diets for reproduction studies and were found to perform well with both proteins.

Additional data from this same experiment are shown in Figure 2. The uppermost bar graphs again compare the weight gain data seen in the first figure. Protein efficiency is shown in the next set of bar graphs--at 5, 7.5, and 10 percent--casein-lactalbumin is distinctly superior to soybean meal, but with 15 percent or more protein in the diet, protein efficiency values are approximately the same. With both proteins, the efficiency of protein utilization decreases as the level of protein in the diet is increased.

Hemoglobin levels in the next group of bar graphs show that only with 5 percent protein are there low hemoglobin levels with both sources of protein and that with 7.5 percent or more protein, hemoglobin levels are satisfactory. Plasma protein levels shown in the bottom

set of bars are low with 5 percent protein from either source. With 7.5 or 10 percent protein, casein-lactalbumin is superior to soybean, but with protein levels above these, there are no statistical differences between the values found.

We should take a few minutes to describe the protein efficiency test used in our laboratory, since it provides the basis of much of the data which will be presented. Our test diets contain a 10-percent level of protein from the test substance, 10 percent fat (obtained from the fat in the test material plus the necessary amount of corn oil), 4 percent Jones and Foster mineral mixture (1) with 10 p.p.m. fluoride added as NaF, 0.35 percent vitamin mixture (2), Oleum Percomorphum, α-tocopherol acetate, and the remainder dextrin (Amidex, Corn Products Co.). This diet and method of study have been in use for several years and are quite similar to that recently described by Campbell and coworkers (3, 4). Male weanling rats are used in a 4-week study, and the weight gains per gram of protein are calculated. A.N.R.C. casein is used as a standard in each set of assays. Liver fat levels are also determined at the end of each experiment and are useful as additional criteria of protein quality. These are, however, not reported in the present paper.

Figure 3 shows the results of one of the studies in the development of this method--showing the effect of level of protein and sex of the animal on protein efficiency values of a good protein--milk protein and of a poorer protein--a mixture of cereal proteins. It will be noted that the values for the male accentuate the differences between proteins more than do those for the female--and that with more than 10 percent protein in the diet, there is a decrease in the PER value for the good protein, but not for the poorer protein, resulting in less difference between the high and low quality proteins. We also have data on 6- and 8-week studies, but find the 4-week data best. After 4 weeks, protein efficiency values fall markedly with good proteins, but not with poor quality proteins.

Figure 4 shows the protein efficiency values for some soybean formula products. Data on some liquid products, shown on the left, were obtained several years ago in the following manner: Each rat (males and females were used) was allowed an amount of the liquid formula, which provided 1 g. protein per day and was also allowed a constant amount of an otherwise complete protein-free diet to give a total of 48.5 calories. Protein efficiency is reported in terms of grams gained per gram of protein consumed. With soybean product No. 1, protein efficiency was 1.71, whereas with a second soybean formula, the protein efficiency was only 1.12. Evaporated milk tested under these conditions gave a value of 2.65. In another study conducted at that time, soybean product No. 1 gave a value of 1.99 but after additional autoclaving--similar to that used in older processing procedures--gave a value of 1.66.

A problem in evaluating the quality of the protein in liquid products lies in the difficulty in properly diluting these with other nutrients to provide about 10 percent of the dietary solids as protein. Protein comparisons are best at this level. Studies on solving these problems, such as by lyophilization of the liquid formula products, are now in progress in our laboratories. Preliminary data indicate that somewhat higher values may be obtained for some of the products now processed by more modern aseptic canning techniques.

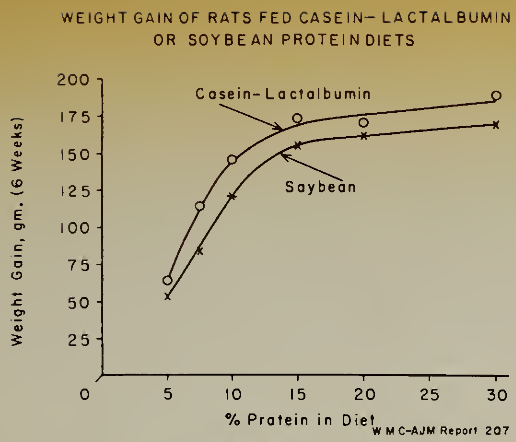
The values for the powdered products, shown on the right-hand part of the figure, were obtained by the regular method described earlier. The values for the powder and the liquid should probably not be in the same figure since they are not comparable. Soybean products 1 and 2 gave values of 2.56 and 2.37, respectively, several years ago, and more recent samples gave values of 2.34 and 2.33, while a third product gave a lower value, i.e., 2.07. A value of 3.11 was found for the casein standard.

Comparison of weight gains of rats receiving these formula products as sole diets have little value, unless the diets are supplemented with missing nutrients, such as vitamins and trace minerals. Under these circumstances, they do test the products as used, even though they provide a higher level of protein and may mask differences in protein quality. For example, in a 4-week study, rats receiving evaporated milk supplemented with trace minerals gained 119 g., whereas animals receiving liquid soybean formula 1, similarly supplemented, also gained 119 g. At these higher protein levels, a difference between soybean and milk proteins is not found.

The feeding of products such as these as the sole diet can, however, uncover specific nutritional deficiencies--other than that of protein quality. Since it was known that soybeans may contain potentially goitrogenic substances, appropriate studies were carried out several years ago on soybean formula products available at that time. Data from one of these experiments, seen in Table 1, show that one of the products had a goitrogenic effect, resulting in enlarged thyroids in the rat. Reports of goitrogenic effects in infants (5) and of additional data in rats (6) have been published. As a result of these, most of the soybean formula products now on the market contain added iodine.

Table 1.--Weight gain and thyroid weights of rats fed soybean formula products

	Weight gain	Thyroid weight
	G./4 weeks	Mg./100 g. body weight
Soybean product 1	125	9.5
Soybean product 2	92	17.7



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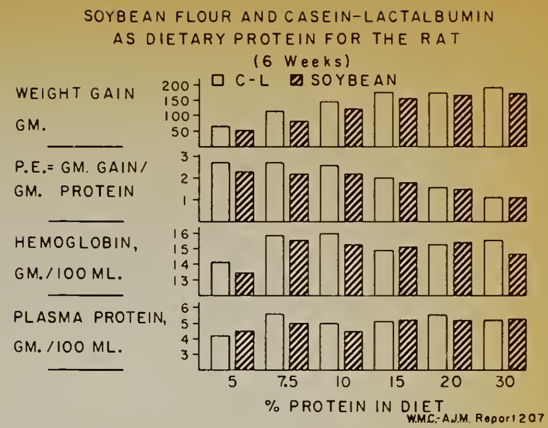

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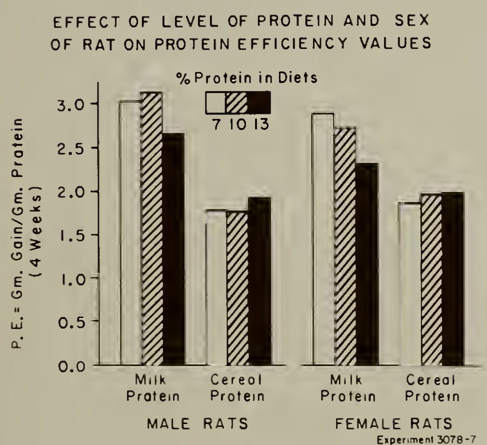

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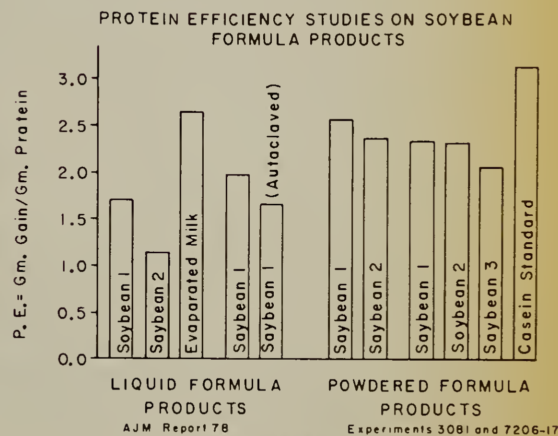

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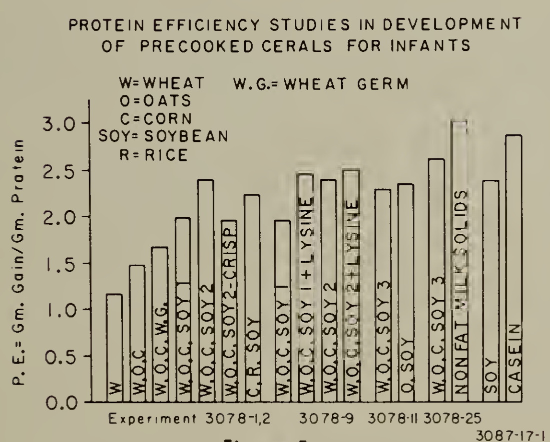

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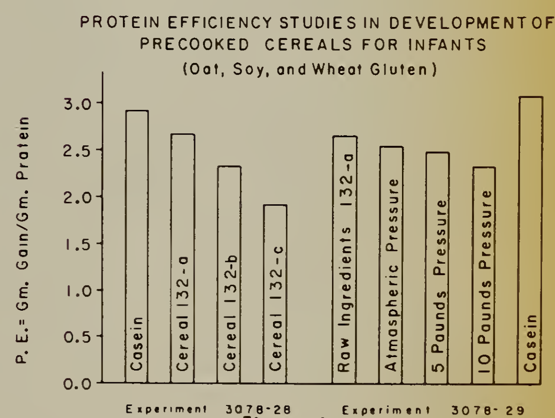

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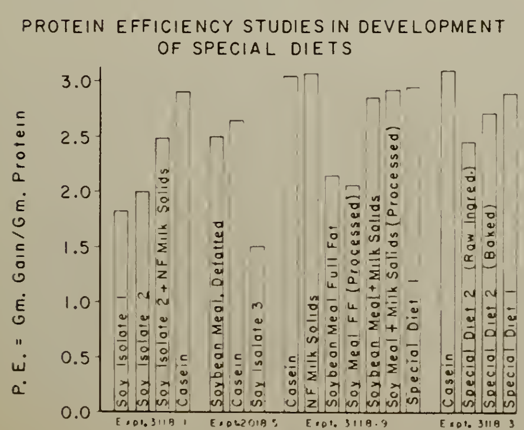

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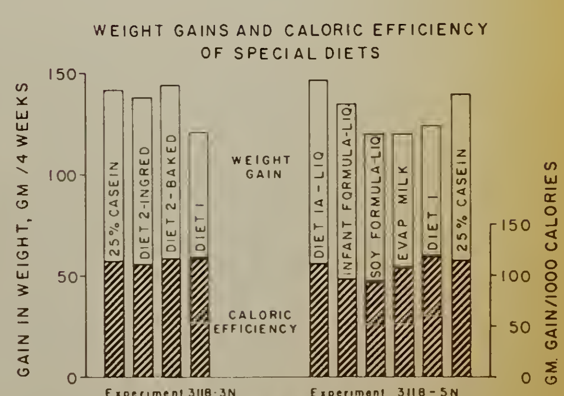

Figure 8.

Precooked Cereals

In the next section, I would like to show some of the protein efficiency values obtained during the course of development of improved precooked cereals for infants. Wheat, oats, corn, and barley were the main cereal grains used in the first precooked, dried, and fortified infant cereals, supplying supplementary protein and minerals to the infant. In studies undertaken several years ago in an effort to achieve even better protein quality in infant cereals, the use of soybean meal was found to markedly improve the protein value. Figure 5 shows some representative protein efficiency values for experimental cereals made with various cereal grains during the course of the development studies. Wheat alone gave a value of 1.17; a mixture of oats, corn, and wheat--1.48--and the inclusion of wheat germ increased this value to 1.67. Inclusion of soy flour raised the value to 1.99 or 2.39, depending on the level of soy flour used. (Including high levels of the soy flour also permitted the level of protein in the cereal to be increased to 25 or 35 percent, as compared with about 16 percent in other mixed cereals). Care in processing of these cereals is very important from the standpoint of both texture and nutritive value. Partial toasting of one of the high soy-containing cereals to give a crisp form resulted in a lowering of the protein efficiency value from 2.39 to 1.96. Another cereal containing soybean, corn, and rice gave a value of 2.23.

In the group of values in the center of Figure 5, it is seen that the protein in the cereal containing oats, corn, wheat, and the lower level of soy flour (W, C, O, Soy 1) could be improved by the addition of lysine, whereas in the cereal containing the higher level of soybean (W, C, O, Soy 2), lysine had very little effect. Values for other cereals are shown in the remainder of the figure. An oat and soy combination, which also gave a high level of protein, had a very good protein efficiency value--2.35. Another good mixture was that of oats, corn, wheat, and a high level of soy meal, giving a value of 2.61, as compared to 3.01 for nonfat milk solids. The value for a soybean cereal itself was 2.38, compared to 2.80 for casein.

Figure 6 shows some other experimental work done on cereals. In the left-hand portion of the figure, the effect of adding various levels of wheat gluten to an oat and soy mixture is seen. As the level of wheat gluten is increased, the protein efficiency is decreased (2.66, 2.36, 1.92). The value for the standard A.N.R.C. casein was 2.92 in this experiment. On the right-hand side of this figure, some effects of processing on protein value are shown. The value for the raw ingredients of Cereal 132-A was 2.65 and after cooking under atmospheric pressure and drying, the value was 2.53. However, as the pressure for the cooking process was increased, protein efficiency values were decreased to 2.49 and 2.34, respectively. The value for the casein standard was 3.07.

From studies such as those described above, cereal formulations have been devised for infants in the past several years to provide very good sources of supplementary protein with high levels of nutritional value.

Special Diets

In the third section, I would like to describe briefly some of the studies leading to the development of specialty nutritional products in which soybean meal has been used as one of the important protein sources. Protein efficiency values for samples of soybean meal and of isolated soybean proteins are shown in Figure 7. Values for some of the soybean meals are good, whereas others are not. Most of the soybean isolates which we have tested have given lower values than the soybean meals. Mixtures of soybean protein or of soybean meal with milk proteins have good protein value, depending, of course, on the proportions used and the quality of the soybean material.

In this figure (Experiment 3118-9), we also see that the processing developed in our laboratories to improve the dispersibility and texture of soybean meal in these nutritional products had no perceptible effect on its nutritional value--either when tested alone or in combination with milk solids. The final product, Diet 1, also retained an excellent protein value (P.E. value 2.94 as compared to 3.06 for milk solids). The last group of bars in this figure shows the protein efficiency values of the raw ingredients for a wafer type of nutritional product (Diet 2) and for the product after baking under optimal conditions. In this particular case, the processing itself improves the value of the protein in the soy meal.

Weight gains of rats fed some of these nutritional products as sole diets (many of these are complete diets) are shown in Figure 8. On the left, the data show that the ingredients of Diet 2 and the final baked form of this diet support weight gains and food efficiency values comparable to that found with a good 25-percent casein diet. On the right, the values for a liquid form of Diet 1 (Diet 1A) are also found to be very good. Iron and other trace minerals were added to the infant formula, evaporated milk, and the liquid soybean formula. The caloric efficiency values for these products were not as good as were found for the casein standard or the special diets.

Another of these diet formulations--Diet 3, containing soybean meal as an important ingredient of the product--was studied through a two-generation reproduction and lactation study. The data are shown in Table 2. On the basis of maintenance of weight during lactation, the number of live young, the weights of the young--at birth, at 5 days, and at weaning--and the percent survival through two generations, the adequacy of this diet is well established.

Table 2.--Test of nutritional adequacy of diet 3--reproduction and lactation study in rats

	First generation (12 rats)	Second generation (14 rats)	Stock rats
Weight, g.			
Before parturition	194	209	190
After parturition	217	236	
At weaning	210	240	
Litter size	8.8	9.9	9.0
Weight of young, g.			
At birth	6.2	5.8	6.0-6.5
After 5 days	10.9	10.5	
At weaning:			
Male	37	46	39
Female	35	43	35
Percent survival			
1 to 5 days	94	84	
6 to 21 days	98	98	

In summary, the studies which were presented briefly this morning show that soybean meals provide protein of good nutritional value for use in (a) infant formula products, (b) in precooked cereal products for the infant, and (c) as an important constituent of nutritional specialty foods. Care and attention must be given to the type of meal or the type of soybean protein used and the processing thereof, in order to insure maintenance of the nutritional value in the final product.

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ADVANCES IN RESEARCH ON THE NUTRITIONAL VALUE OF SOYBEAN MEAL IN ANIMAL FEEDS

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Much information has already been presented during this conference on specific factors related to the nutritional value of soybeans and soybean products. Most of this information applies equally well whether these products are used in the manufacture of human foods or in feeds for animals. Many of my comments will pertain to general developments which have an influence on the utilization of soybeans and soybean products in feeding animals more efficiently. Some liberties have been taken with the term "recent developments," and in some instances considerable periods of time are embraced and in others, information which has not been published will be discussed.

Advances in Our Understanding of Nutritional Requirements

In order to utilize all feed ingredients more effectively and efficiently, it is necessary that we understand as much as possible about specific nutritional needs of animals of different types and ages. During the past several years, many of the gaps in our nutritional requirements information have been filled. We now have a better understanding of the need for specific amino acids by different types of animals and the influence of certain types of ingredients on the need for amino acids. Amino acid needs in terms of protein requirement have been studied with birds of older ages rather than with young chicks under 4 weeks of age. Recently, information has been published showing that practical diets composed largely of cereal grains and soybean oil meal and a protein level of 15 percent or lower, will support normal growth and development of replacement pullets after 8 weeks of age. This is of great importance, since our limited protein supplies can be utilized more effectively to feed larger numbers of animals.

Mineral requirements of different types of animals have also been studied in several different laboratories. The calcium and phosphorus requirement studies with chicks and turkeys from 8 weeks of age to maturity show that levels of these minerals used in practice can be greatly reduced. It is estimated that turkeys do not need more than 0.6 percent of each of these minerals after they are 8 weeks of age. Developing pullet chickens also grow normally and produce eggs satisfactorily later on when raised from 8 weeks of age on diets containing not more than 0.5 percent of each of these minerals.

Improved Methods of Feed Formulation

The feeding of animals is becoming more efficient through increased use of high-speed computors in the calculation of feed formulas. The increased information on nutritional requirements which enables us to set more specific limitations for such calculations makes these techniques more valuable. Rather than computors replacing nutritionists in the feed industry, it is my feeling that such techniques will require nutritionists in greater numbers that are more thoroughly familiar with nutritional problems. A computor can arrive at a feed formula based only on the information that is fed into it. This places greater responsibility instead of less on nutritionists.

Influence of Soybean Meal on Mineral Requirements

It has been shown that certain types of soybeans and soybean products apparently increase the requirement of poultry for zinc. It is not definitely known whether this is due to the fact that zinc contained in such products is bound in an unavailable form or whether some component in soybeans reacts with other dietary zinc to make it unavailable. We have some unpublished data suggesting that unheated soybean protein has the ability to combine with zinc and render it unavailable. After autoclaving, this binding effect was not observed. The addition of chelating agents (EDTA) containing unheated soybean protein either renders the zinc contained in the protein available or prevents the protein from binding with zinc from other materials.

It is thought that this characteristic of soybeans and soybean protein is of little significance in practical feeding applications since soybean meal is subjected to an autoclaving treatment prior to mixing in the feed.

Availability of Fat in Soybeans

Circumstances or economic conditions may at times make the utilization of soybeans in livestock feeding, rather than the soybean meal, a desirability. Recent information on availability of fat in soybeans indicates that special processing may be required if the fat is to be fully utilized. The information in Table 1 shows the difference in absorbability of soybean oil that has been removed from the soybeans and added back to flakes compared with a like amount of oil supplied in the diet with unextracted soybeans. Even though the autoclaving treatments to which the beans and flakes were subjected increased nutritional value, absorbability of fat was only slightly improved. Later information from the Cornell University laboratories has shown that unextracted soybeans subjected to a flaking process prior to autoclaving and incorporating in the diet made the soybean oil equally available. This work was conducted with young chicks. Studies in our laboratory showed that turkeys beyond 8 weeks of age were able to utilize fat from unextracted

soybeans as effectively as fat which was extracted and added back to the diet. It would, therefore, be possible to utilize soybeans without first removing the fat in feeding older birds, providing of course that the soybeans are subjected to appropriate heating processes to improve nutritional value.

Table 1.--Apparent absorbability of soybean oil

Heat treatment	Flakes	Soybeans
None	88	72
10 Minutes, 4 lbs.	95	76
40 " 4 "	95	80
60 " 4 "	96	77

Hill, J. Nutr., 1960.

Contribution of Unidentified Nutritional Factors

There are many scientific reports showing growth stimulation of young chicks by many different types of feed ingredients. Whether these effects are due to specific substances that will eventually be classed as new vitamins remains to be seen. Regardless of this outcome, there are reports showing that soybeans and soybean products have real and significant unexplained influences on performance of animals. Studies in our laboratories show a consistent effect of soybean oil and soybean meal on size of eggs laid by hens fed different types of experimental diets. An example of results obtained with soybean meal is shown in Table 2. A part of this response in egg weight apparently is due to linoleic acid, but it is difficult to explain the response obtained with hexane-extracted meal on this basis. Apparently, however, hexane-extracted soybean meal contains a rather significant amount of phospholipid which is methanol extractable.

Table 2.--Unidentified egg weight factor in soybean meal

Supplement	Average egg weight		
	Pre.	Exp.	Change
			Percent
None	55.3	55.9	1.0
Corn	55.1	57.8	4.9
Soybean meal	56.6	59.4	4.9
Corn oil	54.9	57.6	4.9
Tallow	55.5	56.8	2.2

There are other reports in the literature showing that soybean meal stimulates the growth of young chicks and turkeys when added to purified type diets. Kratzer at the University of California has reported large growth responses in turkeys from the addition of soybean oil meal to a purified diet, and an example of his results is shown in Table 3. Machlin and Gordon, working in the Monsanto Chemical Company laboratories, obtained results which would indicate that soybean protein does not require sources of unidentified factors for maximum chick growth. An example of their results is shown in Table 4. It is difficult to reconcile these differing results; in one instance a very marked growth response was obtained, whereas in Table 4 it would appear that maximum growth was obtained by simply supplementing the diet with methionine.

Table 3.--Unidentified factors in soybean meal

Supplement	Rel. poultry growth	Perosis
None	100	2.4
MeOH - Extd. SBOM	183	1.2
Whey	127	1.9
Egg yolk	109	2.1

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Table 4.--Soybean protein for chick growth

Protein	Supplement	Avg. st. 4 wks.
20 Casein + 13.3 gelatin	-	500
Soybean	Methionine	567
Soybean	-	412
"	0.3 Methionine	537
"	.4 "	603
"	.6 "	618

Influence of Inhibitors in Soybean Meal on Nutritional Value

Much has already been said about the role of inhibiting substances in the nutritional value of soybean oil meal for animals. After reviewing the vast amount of literature dealing with this subject, it appears that the following points should be given careful consideration before making general conclusions concerning the importance of such inhibitors:

(a) The experimental animal used. The conclusions drawn, based on experiments in which the rat is used, do not appear to be valid for chicks and vice versa. The reason for this difference is not clear, but several possibilities exist.

(b) Level of dietary protein. Generally speaking, the experimental diets used for rat work contained a sub-optimum level of protein. In contrast, diets used in chick experiments in which this problem has been investigated contained a level of protein considered optimal or even in excess of dietary needs.

(c) Amino acid adequacy. In many experiments with both chicks and rats where effect of heating has been studied, the diets were deficient in methionine, whereas in other studies the limiting effect of this amino acid on growth was eliminated by use of supplemental amino acid. The increased availability of methionine and cystine by autoclaving, which might partially correct a severe deficiency of these amino acids, would be expected to give a pronounced growth response.

Dye Binding and Protein Quality of Processed Soybeans

In order to produce a soybean meal having maximum nutritional value, the following must be accomplished:

(a) Sufficient heat in the presence of moisture must be applied to bring maximum improvement in nutritional value.

(b) Use of excessive heat must be avoided in order to maintain maximum value after it is reached.

Various methods have been devised to give a quick index to nutritional value of different kinds of protein supplements without resorting to bioassays. Some of these are based on solubility of proteins in different solvents; others are based on amino liberation through in-vitro enzymatic digestion. Most of these methods have objectionable features such as poor correlation with bioassay or difficulties encountered in conduct of the analyses. Some are time consuming and lack precision.

It has been known for some time that reactions occur between proteins and different kinds of dyes. One such reaction is used to

estimate the protein content of single materials such as cereal grains or wheat flours. Uddy published on this method in Vol. 33, Cereal Chemistry, page 190. This method is based on the reaction between the basic amino acids and Orange G.

The damage to protein nutritional value of soybean meal caused by overcooking is due predominantly to the destruction of lysine. It appeared that the dye-binding reaction of proteins with Orange G might give a reliable index to lysine destruction in soybean meal during processing. In order to test this possibility, samples of ground soybeans were subjected to autoclaving treatment for different amounts of time up to 2 hours. These differently treated meals were then fed to chicks and were also subjected to dye-binding tests. The results obtained in this experiment are shown in Table 5. The data show a decrease in dye-binding capacity with increased amount of autoclaving. This decrease became quite large at 60 minutes and longer. This same amount of heat treating also gave a decrease in the nutritional value of the soybean meal. Lysine supplementation corrected the heat damage and this would suggest that dye binding can be used as a reliable index to lysine availability of soybean oil meal. This test has been applied to other proteins such as fish meals and under conditions where methionine and cystine were not severely limited, it was possible to obtain a fairly reliable index to protein quality. Studies are being continued to adapt this method to routine laboratory use for this type of application.

Table 5.--Estimation of nutritional value of soybean meal by dye binding

Heat treatment of soybeans	Dye bound	Avg. chick wt. at 4 wks.	
		No supp.	0.5% Lysine
Minutes at 120° C.	Mg./g. meal		
None	70.8	229	240
15	68.5	312	328
30	68.4	315	347
45	68.5	309	276
60	63.8	293	339
90	63.2	265	313
120	61.2	185	315

Discussion: In response to a question on laboratory methods used to indicate protein quality, Dr. McGinnis mentioned the following: Orange II--used routinely for protein in wheat and flour; nitrogen--Kjeldahl; Orange II--also used for lysine, arginine, and tryptophan.

APPLICATION OF FAO PATTERN IN APPRAISAL OF PROTEIN VALUE

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In 1957, the FAO/WHO Committee on Protein Requirements developed a provisional pattern of essential amino acids based on average minimal requirements of adults and infants for each individual acid, as determined in various laboratories (1). The Committee suggested that the protein value of a single food or of a combination of foods might be predicted by comparing the proportions or patterns of essential amino acids in the food or in the diet with the provisional pattern.

In the provisional pattern the ratios of essential amino acids, including cystine and tyrosine, are expressed in relation to tryptophan, the essential amino acid required in the smallest amount by both adults and children. Table 1 shows the essential amino acid ratios in the provisional pattern with tryptophan taken as unity. Also shown, for purposes of comparison, are the amounts of essential amino acids in the FAO pattern and in milk proportioned to 90 mg. tryptophan, the amount per gram of total nitrogen in cow's milk.

Table 1.--Essential and related amino acids: Ratios in FAO pattern and amounts per 90 mg. tryptophan in FAO mixture and in milk

Amino acid	Ratios	Amounts in mg.	
	FAO pattern	FAO mixture	Milk
Tryptophan	1.0	90	90
Isoleucine	3.0	270	407
Leucine	3.4	306	626
Lysine	3.0	270	496
Phenylalanine	2.0	180	309
Tyrosine	2.0	180	325
Sulfur-containing	3.0 1/	270	213
Threonine	2.0	180	294
Valine	3.0	270	438
Essential amino acid N		238	377

1/ Methionine 1.6; cystine 1.4.

At the level of 90 mg. of tryptophan, all essential amino acids except the sulfur-containing acids are provided in larger amounts by milk than by the FAO mixture. Thus, on the basis of comparison with

the provisional pattern, the sulfur-containing amino acids are the most limiting in milk. The Committee suggested that a protein score might be assigned to a food or combination of foods on the basis of the percentage of the most limiting essential amino acid supplied by the food per gram of total nitrogen as compared to the FAO mixture proportioned to 90 mg. tryptophan. Because milk, per gram of total nitrogen, supplies 213 of the 270 mg. or 79 percent of the sulfur-containing amino acids in the FAO mixture, its protein score on this basis is 79.

The Committee's report listed the amino acid content per gram of total nitrogen for 30 protein-containing foods, the amino acid which appeared to be limiting in each food, the calculated protein scores and reported biological values. The calculated protein scores roughly approximate the biological values which had been experimentally determined in various laboratories. When the report was prepared, the sulfur-containing acids appeared to be limiting in 17 of the 30 foods, lysine in 7, and tryptophan in 6. Since then, however, methods of analysis for some amino acids, particularly for the sulfur-containing acids and tryptophan, have been improved. Recently obtained values, when compared with the FAO pattern, result in a somewhat different picture as to the limiting amino acid in some foods.

To determine the validity of using the provisional pattern for estimating the quality of protein in foods for man, a series of studies on typical protein-containing foods were made under USDA contracts.[1] The major objective of this research was to compare the nitrogen balances of healthy young men and women fed amino acids proportioned as in the FAO provisional pattern and as in the patterns in selected food products, when intake levels of total nitrogen, nonessential amino acids, and the most limiting amino acid in the food under study were kept constant.

Studies have been completed on nonfat milk solids, whole egg, oatmeal, and peanut butter. Preliminary reports have been given at scientific meetings and comprehensive reports are now being prepared for publication.

In Table 2 are listed the essential amino acids for whole egg, oats, and peanuts, per 90 mg. tryptophan, as determined in our Division laboratories. Again the FAO mixture containing 90 mg. tryptophan is listed for comparison. In whole egg to supply 90 mg. tryptophan the amounts of all other amino acids are larger than in the FAO mixture. Thus tryptophan appears to be the limiting amino acid. Oats contain the same amount of lysine per 90 mg. tryptophan as the

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[1] The research under these contracts was conducted under the leadership of Dr. Marian Swendseid at the University of California at Los Angeles, Dr. Dorothy Steel at Oklahoma State University, and Dr. May Reynolds at the University of Wisconsin.

FAO mixture and larger amounts of all other amino acids. Tryptophan and lysine, therefore, appear to be equally limiting. In peanuts, tryptophan and the sulfur-containing acids appear to be equally limiting. The amount of sulfur-containing acids per 90 mg. tryptophan is the same as in the FAO mixture and the amounts of all other amino acids are larger.

Table 2.--Essential and related amino acids per 90 mg. tryptophan in the FAO mixture and in selected foods

Amino acid	FAO mixture	Egg	Oats	Peanuts
Tryptophan	90	90	90	90
Isoleucine	270	333	300	393
Leucine	306	484	518	563
Lysine	270	407	271	340
Phenylalanine	180	284	397	464
Tyrosine	180	137	264	340
Sulfur-containing	270	328	321	268
Threonine	180	276	250	250
Valine	270	348	417	393
Essential amino acid N	238	320	318	349

The amount of nitrogen from essential amino acids in these foods per 90 mg. tryptophan ranges from 320 to 349 mg., as compared to 238 mg. in the FAO mixture.

In the series of studies under contract, nitrogen balances were determined first when essential amino acids were fed as a mixture of purified amino acids, proportioned as in the FAO pattern. Different amounts of the mixture were fed in order to find the minimal level required by each individual for nitrogen equilibrium or a slight negative balance. Next, a mixture of crystalline amino acids was fed which furnished the same amount of the most limiting essential amino acid in the food under study as had been fed at the minimal level of the FAO mixture but with other essential amino acids proportioned as in the food. Then, these same amounts of essential amino acids were fed in the form of the food itself. Finally, the minimal level of the FAO mixture was fed again but this time with the food under study as the major source of essential amino acids.

For all four foods studied, nonfat milk solids, whole egg, oatmeal, and peanut butter, nitrogen balances were better when the diet contained a given amount of the limiting amino acid and other essential amino acids in the proportions in which they occur in the food than

when other essential acids were furnished in the proportions of the FAO pattern. This was true both when the amino acids were furnished in the purified form and when they were furnished as food.

The improvement in mean daily nitrogen balances of six young women fed essential amino acids in peanut pattern proportions as compared to FAO proportions is shown in Table 3. When the two patterns were supplied by crystalline amino acids, the differences in nitrogen balance ranged from +0.15 to +1.12 g. per day; when supplied by the food itself, from +0.01 to +0.57 g. per day. In all 12 comparisons, differences were in favor of the food pattern, although 2 and possibly 3 of the differences may not be biologically significant.

Table 3.--Improvement in mean daily nitrogen balances: Peanut vs. FAO pattern of essential amino acids

Methionine equivalent	Subject	Differences in mean daily N balance on peanut vs. FAO pattern furnished by--	
		Crystalline amino acids	Peanut butter[1/]
Mg.		G.	G.
536	DS	+0.23	+0.57
	ES	+.58	+.01
	UL	+1.14	+.39
670	MN	+.15	+.36
	GP	+.72	+.54
804	MF	+1.12	+.55

1/ Plus small amounts of crystalline amino acids when FAO pattern was furnished by peanut butter.

Results similar to those for peanut butter were obtained for milk, egg, and oatmeal as compared to the FAO mixture. In a total of 52 comparisons, better nitrogen balances resulted in 46 cases when the amino acids were fed in a food pattern than in FAO pattern proportions. In four cases the nitrogen balances were approximately the same. Balances were poorer in only two cases.

In these studies the intake of each essential amino acid except the most limiting was greater when dietary amino acids were proportioned as in the food than when proportioned as in the FAO mixture; the amount of nitrogen furnished by essential amino acids was more than 40 percent greater. The improved nitrogen balances observed on the higher intake of essential amino acid nitrogen indicate that the quality of a protein is dependent not only upon its limiting amino acid but also upon the amount of other essential amino acids which

it contains. Thus, in estimating protein value it appears that both the quantity of essential amino acid nitrogen and the proportions of essential amino acids in the food should be considered.

To determine whether nitrogen balance in man is affected by the amount of essential amino acid nitrogen as well as by the amount of the limiting amino acid, an additional study was made under a USDA contract.[2] In this study, young men have been fed the FAO mixture to provide the same amount of essential amino acid nitrogen as supplied when amino acids were proportioned as in the food under study, in this case white flour. The results from this study are not yet available.

Horn and Warren (2), in our Division laboratories, have shown that both the amount of essential amino acid nitrogen in the medium and the amino acid pattern are important for the growth of *Leuconostoc mesenteroides*. In Table 4 the growth of this microorganism is shown on mixtures of crystalline amino acids proportioned as in oats and as in whole egg. One mixture proportioned as in oats contained the same amount of total nitrogen but less essential amino acid nitrogen than the mixture proportioned as in egg. Growth was better on this mixture than the egg mixture at lower total nitrogen levels but poorer at a higher total nitrogen level. When the same amount of essential amino acid nitrogen was supplied by the oats as by the egg mixture, growth on the oats mixture was increased and exceeded or equaled that on the egg mixture at all total nitrogen levels.

Table 4.--Growth of *Leuconostoc mesenteroides* on mixtures of crystalline amino acids proportioned as in oats and as in whole egg

Total nitrogen per tube	Sources of nitrogen mcg./ml.		
	EAAs........73 NEAAs......143 NH_4Cl...... 38	EAAs.........97 NEAAs.......134 NH_4Cl........23	
	Oats pattern	Oats pattern	Egg pattern
Mcg.	Ml.[1/]	Ml.	Ml.
254	4.3	5.6	3.8
508	10.0	13.0	8.9
762	14.7	16.7	14.5
1,016	17.1	18.5	18.1

1/ Titration values in terms of ml. 0.05 N sodium hydroxide.

[2] The research under this contract is being conducted by Dr. Johnnie Watts at the George Washington Carver Foundation.

The amounts of essential amino acid nitrogen as well as the pattern also appear to be important for the growing rat. Howe and co-workers (3) have reported that rats grew equally well on diets containing essential amino acids proportioned as in the FAO pattern and as in casein when the diets contained the same amount of essential amino acids; otherwise, growth was poorer on the diet containing the smaller amount of essential amino acids.

To summarize, healthy young men and women were fed the same amount of the essential amino acid considered limiting in selected foods with other essential amino acids proportioned as in the FAO provisional pattern and with other essential amino acids proportioned as in the food under study. Nitrogen balances were better when essential amino acids were proportioned as in milk, whole egg, oats, or peanuts than when proportioned as in the provisional pattern, regardless of whether the amino acids were furnished in crystalline form or by food. The mixtures proportioned as in food provided larger amounts of nitrogen from nonlimiting essential amino acids than the FAO mixture. In estimating protein value, it appears that the quantity of essential amino acid nitrogen in a food as well as the quality of the pattern should be considered.

Discussion: To clarify a point as to the formulation of free amino acids and protein in the trials cited in her paper, Dr. Oldham indicated that one series used crystalline amino acids in the FAO pattern with no protein; in another series the formulation of amino acids was equivalent to those in oats but in crystal form; in the third series oats was fed; and in the fourth series oats plus crystalline amino acids to adjust total amino acids equivalent to the FAO pattern was fed.

In response to a comment regarding the adequacy of the FAO pattern, Dr. Van Veen stated that the FAO pattern was the best that could be done at the time. There has been the general criticism that the tryptophan values have been high. FAO will hold a conference in 1963 to establish a new pattern. A further remark was that protein value is not determined solely by the limiting amino acid.

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Session V

PROCESSING AND FEEDING VALUE OF FLUID AND DRY SOY MILKS

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TRADITIONAL METHODS OF PROCESSING AND USE OF SOY LIQUID AND POWDERED MILK

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It is a new day when so many important sponsoring organizations join in evaluating the suitability of the protein of the humble soybean to meet the nutritional needs of the human subject, and to study practical ways of extending its benefits in protein deficient diets.

In August 1940, I presented a paper entitled "The Role of the Soybean in Human Nutrition" before the American Soybean Association at Dearborn, Michigan, and predicted that the day would come when we would find an awakened interest in this country in utilizing soy products as a part of the American menu. I believe we are rapidly approaching that goal. There is now an awakening in many lands to the needs of better nutrition, and it is timely that study and research be given to how we can utilize the values of the soy protein for universal race betterment.

Soybeans have for centuries been the chief protein supplier in the heavily populated areas of Southeast Asia. It is well to examine methods of processing and utilization as practiced in the Orient. However, the per capita utilization of soybeans has been far below their needs, ranging from 15 to 50 pounds per annum in countries like China, Japan, and Korea, largely due to the inability of agriculture to keep pace with population.

It was in these soy-producing and-utilizing countries that I had opportunity over more than half a century to observe their methods of preparation, and to check the results in the feeding of soy products. Considerable leafy vegetables, stems and "roots" have to a certain extent supplemented the diet with protein, so that adults of mature age probably get adequate protein. However, the appalling infant mortality and adolescent protein deficiency diseases have stressed the need for increased rations such as may be supplied by the soybean.

Protein has its greatest contribution during the growing years of life. Three times the amount of protein per unit of body weight is needed the first year of life compared with the adult. During adolescence and the teenage years twice the amount of protein is required till they attain their normal body weight as in after life. If individuals are well grown with ample biologic protein their chances for long life expectancy are enhanced.

With the infant's short intestinal tract and its immature digestive juices foods have to be reduced to liquids to be usable. Consequently, a liquid food beverage, if supplied in sufficient quantity and quality, enables normal growth to proceed rapidly. Without it, growth is stunted; anemia, infection follows and many do not survive these years of inadequate food intake. Those that survive childhood often die early in life of degenerative diseases.

The need of liquid nourishment following birth is evident from the fact that all mammals, including the human, have no provision for taking solid food, so as a starter food a lacteal secretion is by nature supplied, and to meet the need of the growing years of the human, various animal milks have been used. However, the supply is meager in the Afro-Asiatic countries.

My attention was called to soybeans as a dietary food upon reaching China and living on Chinese cuisine. It was some 20 years later, in 1925, that I embarked on the development of a liquid beverage from the soybean. Considerable progress has since been made in improvement of such a food beverage and its use. However, it is only a few areas where nutritional use is made of soy milk, and much remains to be done in its improvement and distribution to combat malnutrition.

The Oriental approach to processing the soybean is entirely opposite to that of the West. Western countries process the soybean by grinding it into fine flour after dehulling, and screening through very fine 200- or 300-mesh screens, or shall we call it, the milling operation. While in lands where soybeans have been used for centuries, they first hydrate the beans, or as we call it, use the wet-milling operation.

In Eastern countries interest in soybeans has been primarily in its protein content, while the West has vied for its oil. It was my good fortune that I began my study of the soybean in the Orient where soybeans were used for human food, rather than for animal rations. Soaking the hard, dry bean was the first procedure, and it then is ground into a milklike slurry. The whole soybean is given a water soak for 8 hours, or after dehulling a water bath for 2 hours. In either case the bean doubles its original weight by water intake. It is then ready for the milling operations. This is accomplished with stone buhr mills, or disintegrators, that break up the continuity of the fiber, and expose its nutrient particles of protein, oil, carbohydrate, vitamins, and minerals to a water wash. The water-soluble nutrients are separated from the fiber portion by filtration. The amount of water used in the slurry mix, its temperature, whether hot or cold, and also the quality of beans, determines the ratio of soluble nutrients to those still clinging to the fiber.

In fact, there are numerous techniques to be observed to get the dispersible protein and other nutrients in the highest soluble amounts. Beans differ, as also the aging of beans. The nutrient yield is greatest immediately after harvest time. Long heat exposure in warm climates, makes for less solubility. A proper soak is of great importance; then next the grinding of the beans. A small stream of water to give a tearing, rubbing action so as to thoroughly expose all soluble ingredients is preferred to a mill with a cutting action to mince into fine particles. Before filtration this slurry should be agitated and heated, which will yield an additional 10 percent to the soluble ingredients. Several methods of filtration, such as a shaking screen, a plate and frame press, vacuum drum filters, or centrifuges of various types can be used. A re-grind of the fiber cake and a second extraction makes possible an extra 5 to 8 percent recovery of the solubles. A possible 92 percent of protein with other nutrients in proportion has been attained by grinding and filtration methods. In practical plant operations we expect 60 to 80 percent protein recovery of the original bean. This leaves considerable nutrients in the fiber or pulp, which is then used for stock feed.

The milky solution thus extracted is used either for cheese curds of various types, or is formulated and processed into a beverage milk--liquid or powdered. Soybeans are used in different countries in making a savory sauce, called Soy Sauce; a soup base as in Miso, or as a fermented bean as Japanese Natto. They are eaten as immature green beans in pod or shelled and are very delicious.

Soy Milk

Trials have been made in the past to utilize soy milk by the Asiatics, but for lack of proper processing methods such milk, as filtered and not formulated, was neither tasty nor nutritionally acceptable, giving rise to very unpleasant digestive responses. I have repeatedly asked in parts of China, Japan, and Korea why it was not used as a beverage, always with the same answer, that it gave rise to intestinal disturbances. So a cheese curd is used instead of milk.

Curdling it into a cheese, through the use of calcium salts, vinegar or other coagulative agencies, has resulted in many savory food products. Heating this milk extract causes a scum film to form, also very tasty, and the remaining portion is curdled and made into cheese cakes of varying dimensions and density. All such sheets and blocks of curd receive a second cook, or are fermented, which seems to render them more digestible.

Soy cheese or curd is easy to market and very popular, being tastily flavored and combined in the Chinese cuisine as a meat, fowl, and fish replacer. The Japanese report 70 different forms or dishes utilizing soybeans, and the Chinese even more. Out of 1 pound of soybeans they make 4 pounds of curd called Tofu.

While we have spent some time in Indonesia we have had little experience with Tempe--a fermented soybean food product.

My contributions had to do with developing an easily digested and highly nutritious soy milk, and processing it sufficiently to render it acceptable to both infants and adults. The extract from the bean which is rich in protein can be formulated as desired with added fat, carbohydrate, minerals, and vitamins. These properties can be varied or formulated to that of human milk, or any other type of animal milk. The final product can be made in a single strength, or condensed to double strength and canned, or spray-dried as a powder.

Our first work in developing a formulated soy milk dates back 36 years ago when we secured a Disper mill, or homogenizer, to constitute a formulated liquid. This soy milk was first used in the Shanghai Sanitarium and Hospital as a table beverage for nurses, helpers, staff, and patients of the institution, and later to the baby and children's ward of the Shanghai Clinic and Hospital. Here we had baby boarders, infants kept under observation on soy milk feeding for up to 2 years. The results of this feeding was reported in the China Medical Journal of 1937. Many other farmed out research studies were made, such as at the indigent hospital in the Philippines; at the Tokyo University, and the Ohio State University in America. Results on the Ohio State study are shown in Figure 1.

The first commercial development was a soy milk dairy established in Shanghai in 1935, the process used was in-bottle sterilized milk, formulated to the standard of cow's milk; also a chocolate milk; and a soy-acidolphilus milk, which was extensively marketed all over the city of Shanghai up until the plant was destroyed in 1937 by the bombing of Shanghai.

A soy milk powder plant was also fabricated there, using a local made Grey Jensen spray dryer, which also came to an end in the same way at the same time.

There are many technical problems involved in producing a satisfactory nutritional beverage from the soybean to simulate milk, which in the few moments we have would be impossible to enter into. These are gradually being solved, such as improved color, taste, stability, condensing as a double strength canned milk, and as an instant soluble powdered soy milk. On vacuum pan evaporation, due to the viscosity of soy milk, concentrating to more than 30 percent solids is the limit, as compared with animal milk at 45 percent solids. However, generally speaking, once a water extraction soy milk is obtained the same methods and equipment used by the dairy industry are applicable to produce it in various forms for marketing.

Once we have obtained a fiber-free milklike fluid from the soybean, containing the water dispersal nutrients of protein, oil, carbohydrate, minerals, and vitamins processed to make them nutritionally

acceptable, it now becomes a question as to formulation. No standards have yet been set for the resulting formula. Composition of soy milk today has been a matter largely decided by the respective manufacturers.

Dr. E. A. Ruddiman working in the early 40's at Dearborn with the Ford Foundation, tackled this subject in a paper to the A.S.A. suggesting that cow's milk be the standard. Few pediatricians today accept that for infant feeding.

We know fairly well what are obtained from the hydrated bean with 7 parts of water to 1 part of bean by weight; namely, 3.64 percent protein; 1.8 percent fat; and considering 40 percent of carbohydrate to be edible, a usable 1.5 percent dextrines, sucrose, and starch. In brief, the edible entities extracted from the soybean of fat and carbohydrates are each half that of the protein.

To this, additives can be added to formulate human milk, cow's milk, cream, and ice cream mixes of any variation desired. The types of beans used, methods of manufacture, causes variation in availability of nutrients and elements found in various preparations, so that chemical formulae do not always coincide with usability of nutrient.

Thus far I have dealt with a nonfiber soy milk made either from the whole soybean, or dehulled, using only the cotyledons. This is the practice of the Orient and it is my belief that human nutrition is so important that we can afford to sacrifice to animal feed the fiber and small amount of ingredients that cling to it in order to obtain the rich ingredients in soluble form. It is still economical compared with other similar products on the market.

However, some researchers have been making milk from the whole dehulled soybean used in entirety, giving us 3 percent fiber on a dry basis. For older children and adults this can do quite well when formulated. We have objected to the fiber on the grounds that animal milks are fiber free, and on coagulation we get a rough, tough curd as compared with a smooth, jellylike curd made from a fiber-free liquid.

Isolated protein, either in entirety or combined with raw soy milk can be processed and formulated into a fiber-free milk. Here we need to be careful of having the proper additives. We have made fiber-free milk from the 70 percent soluble soy flakes or grits, and when fortified with vitamins and minerals, good growth records have resulted in animal feeding.

We may say that protein is protein from the soybean, but too long processing at too high temperature, and too much exposure to chemical changes leaves a question in our minds as to whether we destroy its soy nutritive values. We do know that all soy milk needs a heat treatment above boiling to destroy the trypsin inhibitors.

The one outstanding problem of soy milk, whether from the whole soybean, or its extracted solubles, is a characteristic soybean flavor. Since soy milk looks white like animal milk, those accustomed to animal milk think it should taste like cow's milk, especially since it is called a milk. The dairy people object to the word "milk" used in reference to soy milk, claiming the term "milk" designates an animal secretion.

Trying to overcome this prejudice of the laity has led to much experimental work. We shall not be able to simulate the taste of cow's milk unless we use some derivative of animal milk, but we can mask the soy flavor by processing methods, also by additives of distinctive flavors.

I wish to conclude this paper by referring to the widespread possibilities of the utilization of the soybean, and the economics involved. We assume that for adequate nutrition all nations of mankind need a milk beverage, especially in the very earliest years of life to promote adequate nutrition. The possibility of achieving this lies only with the soybean. The human,as well as all other mammals, require a milk for post-natal feedings. Soybeans can make this possible for the entire human race through improved and extended agricultural production and efficient processing methods, and within the reach of the meager economies of nations.

Using the formula of animal milk, from 1 pound of soybeans we can obtain sufficient protein extracted to formulate a gallon of milk. This pound of soybeans yields all needed protein, half of the required oil, and some of the edible carbohydrate. The B vitamins, together with some minerals are present, and other vitamins can be added at low cost. At the market value of the sum total of constituents needed to constitute a gallon of formulated vitamized soy milk less than 15 cents is required, and these figures answer quite well for most parts of the world. While vitamins cost more in certain areas than they do here, added carbohydrates and the oil is cheaper in certain areas. The greatest expense, of course, is in processing equipment. Low-cost small pilot plants operated by cheap labor in countries of low economic resources seem very practical. These figures and statements are verified through the operation of several small pilot plants in Southeast Asia countries. The United States and China produce soybeans abundantly, and with the rising prices of soybeans, they are still the best buy of any agriculture product produced from the soil when their contained nutrients are used to sustain human life.

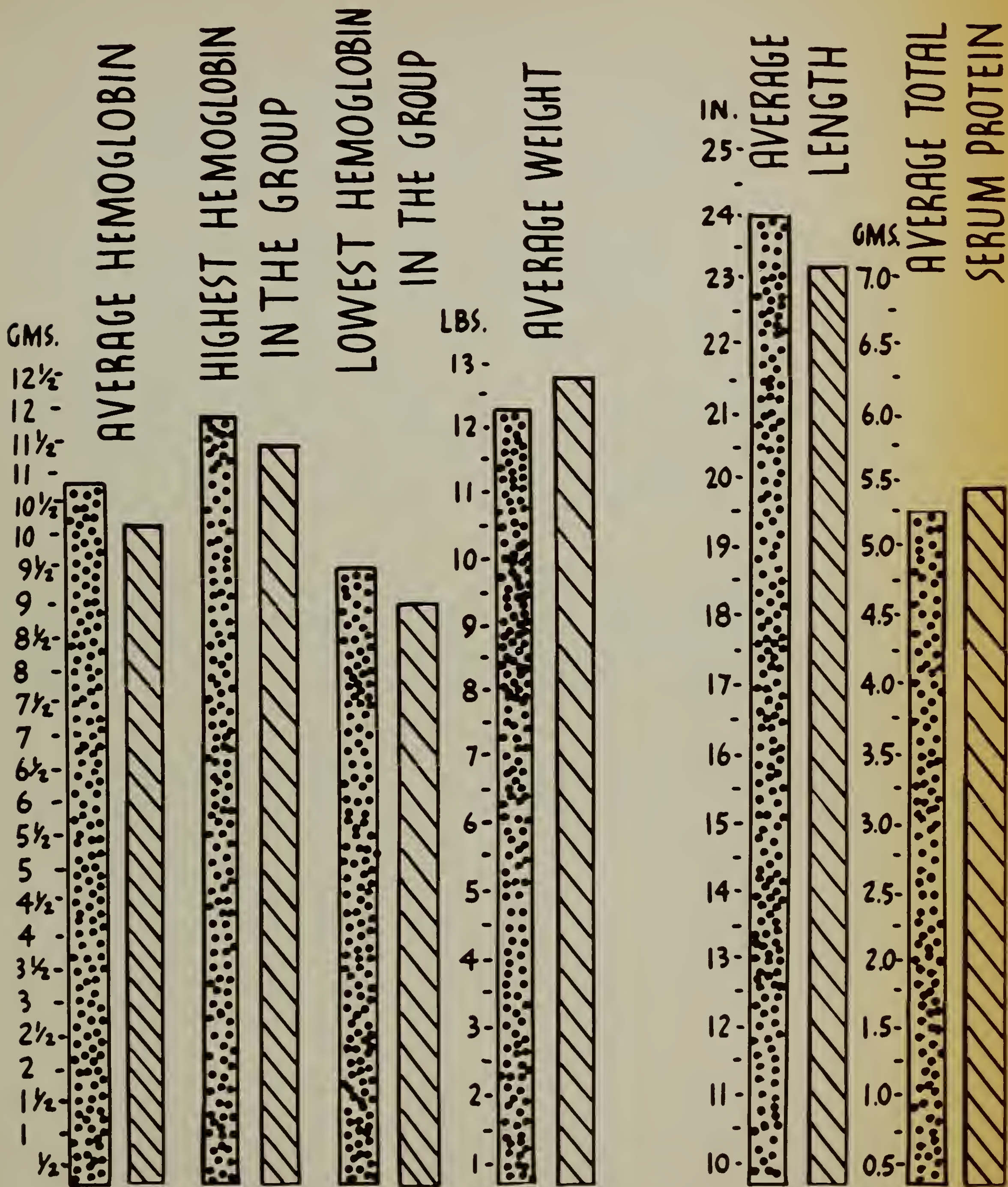
It must be remembered that nearly all Afro-Asiatic people cannot afford containers, or the overhead cost of merchandising. They live largely on foods they produce and prepare at a consumer cost little above what the agriculture producer gets for his crops.

LABORATORY AND X-RAY FINDINGS

of the

CLINICAL LABORATORY, CHILDREN'S HOSPITAL, COLUMBUS, OHIO

During and at the End of 3 Months' Feeding Test



The 17 infants' average indicated by dots were on soybean milk (Soyalac), and the 9 infants indicated by lines on standard cow's milk formula as controls. The soy milk babies lead the higher mark for average growth in length, and also in grams of hemoglobin, while the cow's milk infants gave a better average weight gain. There was very little difference in the average Total Serum Protein in either groups.

Figure 1.

The soybean is rightly called, because of its comparative wealth nutritionally, "gold from the soil." It ranks as the most outstanding product Americans can export if rightly processed for world nutritional relief. Great progress has been made in the adaptation of soy formulated foods for animal and pet diets.

The soybean, in the light of what roll it has had in preserving the millions of Southeast Asia people for centuries, deserves the combined efforts of scientists, nutritionists, and financiers to lift it into a human acceptable and economical available food.

The soybean is variously called "gold from the soil" or "meat without bones." With its multitudinous variety of ways to incorporate it in the human diet, I would like to give one more fitting title to it as a "universal protective factor of diet." Animal milk has served this role in Western lands, but is of limited availability. Soybeans incorporated in the national diets as a milk and cheese, and its many other recipes, if supplied in adequate quantities insures balanced nutrition. It is a body builder from infancy to the age limit. It is unique compared with other agriculture products in that it is available as a liquid, curd, or solid, as whole beans and flour.

Yet, as a food supplier, the soybean has had little scientific research or the help of modern trained technicians. We still harp back to the know-how of the Oriental people who have learned to relish the soybean and know of its building power, and enjoy its energy yield.

We depend on flash pasteurization and a vacuum pull to de-bitter the beany odor and taste, but no one has come up with the answer, to what it is and from what it comes--the fat or carbohydrate component. We have had some success in a cheddar cheese, but so far have not been able to make a cheese that melts. It is to be hoped as a result of the study and interest that prompted this assembly that chemists, technicians, and dietitians, along with the agriculturists, can solve these interesting problems. It may be that an agronomist will come up with a new soybean with a delicious flavor.

PILOT PLANT STUDIES ON SOY MILK[1]

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When a freshly prepared water extract of soybeans is dried, it loses much of its similarity to milk with respect to its solubility and opacity. While there is some question whether the dried product can rightly be called milk, common English usage permits this for soy powders intended for use as a beverage. A practical definition of dried soy milk might include soy preparations, readily dispersible in water and containing fat. Whether this definition is generally acceptable or not, it can be used for the purpose of this report to restrict the number of soy products under discussion.

The purpose of this investigation was to develop improvements in the process for making dried soy milk for use in developing areas of the world and, in particular, the process in Indonesia at the plant equipped by UNICEF. It was decided to use whole soybeans as the starting material (instead of a defatted product) since many areas in the world do not have facilities for expelling or extracting oil.

The two principal types of soy milk which were studied are presently in commercial production in this country. The first was a spray-dried water extract of soaked soybeans and the second, a homogenized, spray-dried slurry of dehulled soybeans. Two other soy fractions were investigated, namely, the acid-precipitated curd from the water-extracted soy milk and also the homogenized slurry from dehulled, soaked soybeans. The four products were compared with respect to yield, flavor, and protein efficiency in promoting growth of rats.

Interrelation of Soybean Fractions

Figure 1 shows the distribution of solids and nitrogen in the fractions made by water extraction of soaked soybeans. In addition to the soy milk and acid curd, the residue from the water extraction was collected as was the whey from the precipitation of the curd. The maximum possible yield of solids in the manufacture of water-extracted soy milk is 65 percent. About 23 percent of the soybean solids, in addition to the hulls, are lost in the insoluble residue. In the manufacture of acid curd, the theoretical yield is 49 percent

1/ This investigation was supported in part by a Grant from the United Nations Children's Fund.

2/ Presented by Dr. Hand.

and 16 percent of the solids is lost in the whey. The loss of solids in the whey may not be entirely disadvantageous since deleterious substances may also be removed in the whey.

The yields of nitrogen in the milk and the acid curd are more favorable than the yields of solids because the discarded fractions are relatively low in nitrogen.

Figure 2 shows the distribution of solids and nitrogen in the fractions made directly from dehulled soybeans. The dehulled soybeans contain 90 percent of the original solids and 96 percent of the nitrogen, the only losses being in the hulls. The soaked dehulled soybeans contain 80 percent of the original solids and 90 percent of the nitrogen. It remains to be seen if removal of deleterious substances is accomplished by the soaking.

There are, of course, many other soy fractions of potential interest for utilization in human foods[1] but a consideration of these does not fall within the scope of this investigation.

<u>Procedure for Pilot-Plant Production of Full-Fat Soy Milk Fractions</u>

a. <u>Spray-dried soy milk by water extraction (Sample 68)</u>

Clark soybeans were soaked overnight in tap water (water, 3-1). The soak water was discarded. The soaked beans were ground through the 0.023" screen of a Rietz disintegrator (E12)[2] using 1 gallon of water (140°-150° F.) to 1 pound of dry beans. The slurry was filtered through a plate filter (E15). The milk was cooked by passing it through a heat exchanger and it was held at 250° F. for 10 minutes. It was concentrated to 16 percent solids in a wiped film evaporator (E3) and spray-dried at 410° F. inlet/200° F. outlet (E10), using a nozzle pressure of 425 pounds (E5). The dry powder was packed under nitrogen and sealed in number 10 cans (E1).

Figure 3 shows the flowsheet for the pilot-plant production of spray-dried soy milk by water extraction of soybeans.

b. <u>Soy milk from dehulled soybeans (Sample 81)</u>

Soybeans were size graded in a pea grader equipped with special screens (E6). The hulls were loosened and the antitrypsin was inactivated by steaming in an autoclave for 45 minutes at 212° F. The moisture was removed from the seedcoat by drying for 10 minutes at 220° F. in a tray dryer (E9). The beans were then dehulled by passing through a burr mill (E2). The setting on the burr mill was

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[1] A. K. Smith and W. J. Wolf. Food Uses and Properties of Soy Beans. I. Food Uses. Food Tech. <u>15</u>, 4 (1961).

[2] Numbers refer to appended "Pilot-Plant Equipment for Soybean Milk Line."

adjusted for each size grade to prevent cracking the cotyledons. The hulls were separated from the cotyledons by passing them over a gravity separator (E8). The dehulled beans were ground in a comminuting mill (E7) through a number 40 screen and slurried with warm water at 140° F. to a 16-percent slurry. The slurry was passed through a homogenizer (E4) at 2,000 p.s.i. and spray-dried (E10) at 420° F. inlet/210° F. outlet using a two-fluid nozzle (E16) at a product pressure of 38 pounds and an air pressure of 44 pounds.

Figure 4 shows the flowsheet for the production of spray-dried soy milk from dehulled whole soybeans. It should be noted that a homogenizer is needed in this line but an evaporator and filter are not required. To protect against abrasion the pistons of the homogenizer were coated with stellite.

c. Soy milk from soaked dehulled soybeans (Sample 82)

For the preparation of soy milk from soaked dehulled beans, the procedure was the same as for the unsoaked beans until after the dehulling step except that the initial autoclaving to loosen the hulls was limited to 2.5 minutes at 212° F. The dehulled beans were soaked overnight in an amount of water three times the weight of the beans. The beans were drained and steamed for 45 minutes at 212° F. The steamed beans were passed twice through the 0.023" screen of a Rietz disintegrator (E12) using water sufficient to make a slurry of 16 percent solids. The slurry was homogenized at 2,000 p.s.i. (E4) and spray-dried (E10) at 410° F. inlet/200° F. outlet using a two-fluid nozzle (E16) at a product pressure of 38 pounds and an air pressure of 44 pounds. The dry powder was packed under nitrogen in number 10 cans (E1).

This sample contained all the components of dehulled soybeans except some of the diffusible, water-soluble substances.

d. Spray-dried acid curd (Sample 67)

The same procedure was followed as for making water-extracted soy milk through the stage of heating at 250° F. for 10 minutes. The milk was cooled to 150° F. and sufficient 0.04 percent acetic acid mixed with the milk to cause the curd to separate from the whey. The curd was drained on cheesecloth and pressed in a hydraulic juice press. The press cake was ground twice through the 0.023" screen in a Rietz disintegrator (E12) with enough water to make a 16-percent slurry. This was homogenized at 2,000 p.s.i. (E4) and spray-dried (E10) using a two-fluid nozzle (E16) at a product pressure of 38 pounds and an air pressure of 44 pounds. The dried powder was packed in number 10 tins (E1) under nitrogen.

This sample differed from the water-extracted soy milk by the removal of the soluble components of the whey. Any excess of acetic acid was removed during the drying.

e. Soy milk residue (Sample 64)

The soy milk residue consisted of the filter cake from the soy milk manufacture with the only change in procedure being the removal of the hulls after soaking and before slurrying in the disintegrator. This was accomplished by treating the soaked beans in a vegetable peeler (E11) and separating the hulls from the cotyledons by repeatedly agitating in water and decanting.

This fraction contained all the water-insoluble ingredients of the soybeans except the hulls.

Indices of Quality in Relation to Processing Conditions

The details of the analytical procedures used to define the quality of soy milks will be published separately (J. P. VanBuren et al.).

The proximate analyses given in Table 1 show some interesting differences between the fractions. The percentage of bound fat is highest in the milk made by the water extraction method. Carbohydrates are the principal ingredients in the residue from the water extraction. Little is known about the composition of the carbohydrates and proteins in this residue (Smith and Wolf, 1961).

Table 1.--Composition of soy milk samples

Fraction	Max. possible yield	Crude protein	Free fat (ether ext.)	Bound fat	Fiber	Moisture	Other ingredients
	%	%	%	%	%	%	%
Dehulled whole soybeans	90	41.9	21.2	7.1	1.1	2.9	25.8
Dehulled soaked whole soybeans	80	45.0	23.3	7.6	1.9	2.9	19.3
Water extract of soaked soybeans	65	49.4	13.1	15.6	0.1	3.2	18.6
Residue from water extract (minus hulls)	24	21.2	9.7	6.3	9.6	4.9	48.3
Acid curd	49	57.5	30.4	7.4	0.2	2.3	2.2

Destruction of 90-91 percent of antitrypsin occurs with the degree of heat (5-10 minutes at 250° F. or 30-45 minutes at 200° F.) that also produces optimal Protein Efficiency Ratios for these soy products. Destruction of urease by heat is much more rapid and is not a good measure of adequate heat treatment.

Overheating soy products results in loss of available lysine, and increase in the degree of browning. Changes in these two indices run parallel with decrease in nutritional value (Protein Efficiency Ratio).

The percent of soluble solids in a soy product is not a very reliable indication of the amount of heat treatment because the change in soluble solids depends on the conditions. Heating soybeans with steam or increasing the temperature during drying produces a consistent decrease in soluble solids. However, during heating of fluid soy milk the soluble solids pass through a minimum when measured in the final dried product.

This makes the value for soluble solids difficult to interpret. Perhaps the solution to the problem would be to set up a specification for soluble solids that would limit both the upper and lower permissible values.

Since some soy products exhibit oxidative rancidity, measurement of peroxide values provides an indication of stability on storage. In this series of samples, low peroxide values result when the heat treatment is applied to the beans before grinding.

Dry soy milk from whole soybeans was readily dispersible in water without an added dispersing agent, and the suspension was slightly more stable than a similar suspension of the dried water-extracted soy milk.

Nutritional Assessment

In order to establish processing conditions, samples produced in the pilot plant have been subjected to rat growth tests. The details of this study will be reported in a separate publication (L. R. Hackler *et al.*). Drying has no damaging effect on nutritional value as long as no browning or destruction of available lysine occurs. Based on growth rates and Protein Efficiency Ratios, equally good products can be obtained by spray drying, vacuum roll drying, atmospheric roll drying, or freeze drying. Economic considerations would favor the use of atmospheric rolls. Drying, alone, without an additional heat treatment, does not inactivate the antitrypsin. Overheating at 250° F. for more than 10 minutes damages soy products, but there is little or no damage at 200° F. for as long as 6 hours.

The soy milk samples were submitted to a taste panel for evaluation of both flavor and consistency and the results are summarized in Table 2. The water-extracted soy milk received the highest scores, but the differences were slight and all the samples were found acceptable except the acid-precipitated curd. Differences in the smoothness of the suspensions was noticeable and this may have influenced the flavor scores. The grittiness of the acid-precipitated curd was objectionable.

Table 2.--Taste panel comparison of soy milk samples

Fraction	Average scores	
	Flavor	Consistency[1]
Dehulled whole soybeans	6.1	6.8
Dehulled soaked whole soybeans	5.2	5.8
Water extract soaked soybeans	6.7	8.1
Acid curd	1.8	1.8

1/ Absence of gritty particles.

Soy milks do have flavor defects. Efforts to eliminate these defects have led to the development of a considerable number of soy fractions such as protein isolates, as well as acid and alcohol extracts.

As shown in Table 3, all the fractions had satisfactorily high Protein Efficiency Ratios. The lowest was the water-extracted soy milk and the highest was the milk made from whole soybeans. It was especially interesting that the insoluble residue, discarded in the water extract method for making soy milk, was actually superior in its Protein Efficiency Ratio to the milk itself. The residue produced the highest growth rate of all the soy fractions, and the water-extracted soy milk had the lowest growth response. In animal tests the milk from whole soybeans was comparable to casein at the 10-percent level in the diet.

Table 3.--Nutritional comparison of soy milk samples
rat growth tests

Fraction	Daily gain	Food intake	Protein efficiency ratio
	G.	G.	
Dehulled whole soybeans	4.43	16.11	2.70
Dehulled soaked whole soybeans	4.30	15.9	2.57
Water extract of soaked soybeans	2.73	13.8	2.05
Residue from water extract	5.03	20.2	2.47
Acid curd	2.60	11.3	2.32

Samples of these soy milk fractions have been sent to Dr. Paul György for a more detailed study of their nutritional value.

Conclusions

Dry soy milk of superior quality can be made directly from whole soybeans without including a water-extraction step. The yield is better, and the power and labor costs are reduced. In the direct manufacture of dry milk from whole soybeans a homogenizer is added to the processing line but the evaporator and filter press are eliminated.

Pilot-Plant Equipment for Soybean Milk Line

1. American Can Company, Maywood, Illinois
   Model L Western Closing Machine

2. Bauer Bros. Company, Springfield, Ohio
   No. 148-2-E 8" Laboratory refiner

3. Blaw-Knox Company, Buflovak Equipment Division, Buffalo, New York
   4 sq. ft. Laboratory agitated film-type evaporator

4. Cherry-Burrell Corporation, Chicago, Illinois
   Size Jr. 75 Viscolizer (Stellited pistons)

5. Delavan Manufacturing Company, West Des Moines, Iowa
   Type SDS high pressure nozzle with distributor AA and orifice No. 1

6. Ferrell, A. T. Company, Saginaw, Michigan
   Model 297-AS Clipper pea grader (Screens with oblong cross slots 12/64", 13/64", 14/64", and 15/64" by 3/4")

7. Fitzpatrick, W. J. Company, Chicago 7, Illinois
   Model D Comminuting machine

8. Oliver Manufacturing Company, Rocky Ford, Colorado
   Model 5A gravity separator

9. Proctor and Schwartz, Inc., Philadelphia, Pennsylvania
   8 rack, 16-tray Laboratory tray dryer

10. Proctor and Schwartz, Inc., Philadelphia, Pennsylvania
    Model 2A Semi Works spray dryer

11. Reynolds Electric Company, Chicago, Illinois
    Model 14 Vegetable peeler

12. Rietz Manufacturing Company, Santa Rosa, California
    Model RA-4-K53 Disintegrator

Distribution of Solids and Protein in Fractions from Water Extraction of Soaked Soybeans

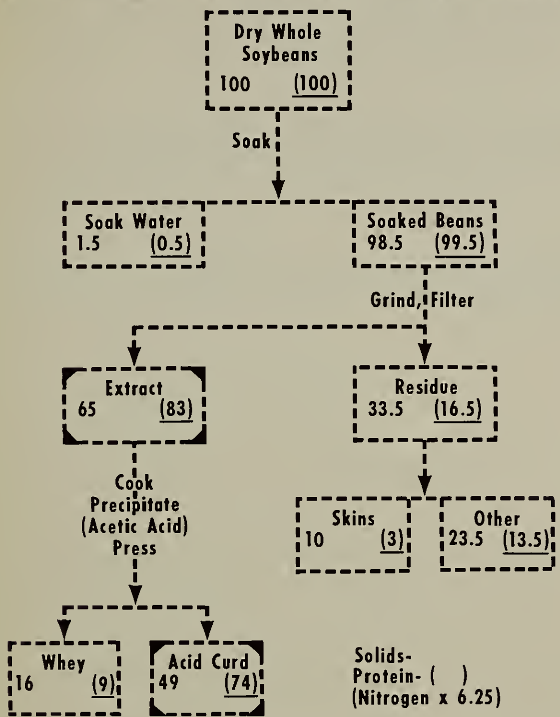

Figure 1.

Distribution of Solids and Protein in Fractions from Dehulled Soybeans

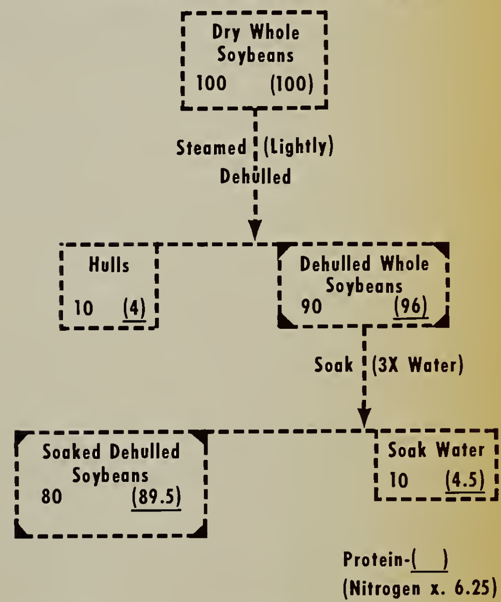

Figure 2.

Flow Sheet for Water Extracted Soy Milk

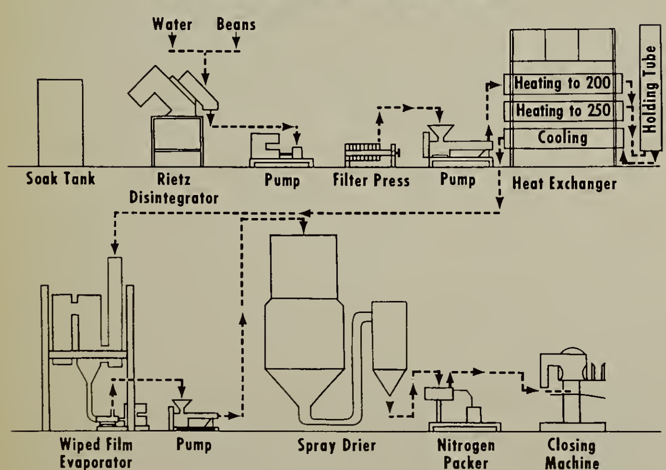

Figure 3.

Flow Sheet for Milk from Dehulled Whole Soy Beans

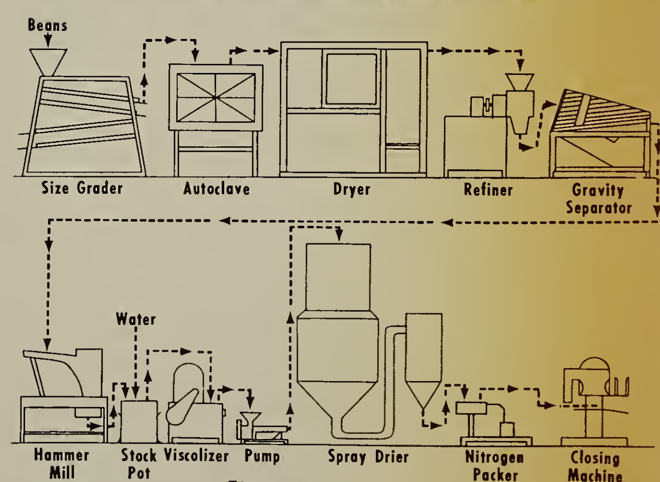

Figure 4.

13. Robbins and Meyers, Inc., Springfield, Ohio
Model F3 Moyno Screw-type pump

14. Robbins and Meyers, Inc., Springfield, Ohio
Model 3L2, type SSQ Moyno 3-stage Screw-type pump

15. Shriver, T. Company, Harrison, New Jersey
Size 12 Filter press (plate and frame)

16. Spraying Systems Company, Bellwood, Illinois
No. 22 Pneumatic atomizing nozzle consisting of fluid nozzle 40100 and air nozzle 1401110

17. Waukesha Foundry Company, Waukesha, Wisconsin
Model No. 2BB Positive displacement pump

PROBLEMS IN FORMULATION OF SOY MILK

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Soy milks have gained widespread use in this country as a replacement for cow's milk for those infants and children who are sensitive or allergic to cow's milk. Therefore, manufacturers have patterned their soy milks after cow's milk, at least as far as the major nutrients are concerned. The similarity in composition of a popular soy milk and evaporated milk is shown in Table 1. The ingredients of this soy milk are shown in Table 2.

Table 1.--Comparison of a soy milk and evaporated milk
(Basis of 100 grams)

Nutrient	Evaporated milk	Mull-soy[1]
Calories	138	130
Protein, grams (N x 6.25)	6.75	6.0
Fat, grams	7.9	7.0
Carbohydrate, grams	10.0	10.0
Calcium, milligrams	243	230
Phosphorus, milligrams	195	150
Total solids	26.3	24.8

1/ Trademark. The Borden Co.

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Table 2.--The ingredients of a commercial soy milk, Mull-Soy

Water	
Soy flour	Vitamin A
Soy oil	Vitamin D
Sucrose	Sodium ascorbate
Dextrose	Thiamine hydrochloride
Dextrins-maltose dextrins	Riboflavin
Tri-calcium phosphate	Pyridoxine hydrochloride
Calcium hydroxide	Niacin
Monoglycerides	Vitamin B_{12}
Potassium iodide	

A comparison of dried whole milk with a low fat and medium fat soy flour enables one to visualize the reasons for the ingredients required for a soy milk (Table 3). When compared on the basis of 100 grams of protein, it is apparent that to approximate cow's milk with a soy base requires the addition of approximately 100 grams of fat, over 100 grams of carbohydrate, over 3 grams of calcium, and over 1 gram of phosphorus.

Table 3.--Comparison of low fat and medium fat soy flour to whole dried cow's milk on a 100-gram protein basis

Nutrient	Whole cow's milk	Soy flour[1]	
		Low fat	Medium fat
Grams			
Protein	100	100	100
Fat	107.5	2.46	15.5
Carbohydrate	147.7	33.8[2]	35.0[2]
Calcium	3.69	0.59	0.55
Phosphorus	2.82	1.41	1.43

1/ Values taken from USDA Handbook No. 8. Composition of Foods, 1950.

2/ Carbohydrate corrected for availability.

In this country, refined vegetable oils are readily available as a fat source. There are no unusual problems with rancidity. Refined carbohydrates are also available and the problem is confined to the selection of those sugars which will produce the desired color and degree of sweetness in the end product. It would be possible to use a natural food as a carbohydrate source if refined carbohydrates were not available. A soy milk must also have added calcium, phosphorus, and vitamins. There are two problems with adding a calcium salt, one is the abrasive action of these salts on homgenizer valves, and the second is their effect on the stability of the emulsion. Both of these difficulties can be overcome by selecting the calcium salts best suited to the available equipment and processing conditions on an empirical basis. Vitamins pose no problem in this country because they are available in synthetic form at reasonable cost. Since cow's milk is generally regarded as an excellent source of vitamins A and D (which is added) and all the B vitamins, these should be added to soy milk. Soy flour is not a potent source of the water-soluble vitamins and is poor in the fat-soluble vitamins. However, soy oil is an excellent source of tocopherols

or vitamin E. The effect of heat sterilization of soy milks on the natural vitamin content, particularly thiamine, must also be considered. In particular, soy is deficient in vitamin B_{12}, as is all plant food, and special attention might be given to its inclusion in a soy milk.

There are other problems in the processing of soy milks common to any processed food, such as microbiological spoilage, stability, flavor problems, nutritional and other problems, all of which may vary according to the area in which the product is manufactured and sold. Some people, but not small infants, object to the flavor of soy milks, particularly the aftertaste. Flavors such as fruit flavors, cola flavors, and chocolate, blend well with soy milks and improve the flavor greatly. In this country, since the principal consumer of soy milk is the allergic individual, flavors (e.g., chocolate) are not regarded as desirable. However, for a non-allergic population, much could be done in the flavor area. Also for the nonallergic population, vitamin levels could be increased by using natural food sources.

Two problems which occur with soy milks, regardless of the population which it is to feed, are those of goitrogenicity of soy and the amino acid supplementation of soy protein. These problems will be discussed in greater detail.

Goitrogenicity of Soy

For some time, it has been known that certain foods interfere with the normal metabolism of iodine. In 1938, Sharpless (1) reported that soybeans produce a goiter in rats which could be completely reversed by the administration of iodide. Sharpless' results have been confirmed by a number of investigators (cf. 2). In contrast to the studies on soybeans, McCarrison (3) and Kennedy and Purves (4) were unable, by feeding iodide, to reverse the goiter produced in rats by feeding seeds of various members of the Brassicae family. The differences in results of the administration of iodide on the goiters produced by feeding of Brassicae and soybeans appeared to have cast some doubt on the efficacy of iodide as a preventative and curative agent for goiter produced by soybeans.

That a soy milk (no iodide added) could cause a goiter in humans when used as the sole source of food was reported by Van Wyk *et al.* (5). Others have reported goiters in infants on noniodine fortified soy milk and most of these reports have been collected and reviewed in recent literature (6).

This development led us to investigate the goitrogenicity of raw soybeans, solvent-extracted soy flour, isolated soy proteins and several soybean infant foods, as well as the effects of addition of iodide to soybean diets when fed to the rat. This work was published this year (7).

When a noniodine fortified soy milk was fed to rats, significant enlargement of the thyroid gland occurred in 1 to 2 weeks. The addition of 160 micrograms of iodine as KI per 100 grams of diet caused the hypertrophied gland to return to normal size in 2 to 3 weeks. This can be seen in Figure 1. It has been determined that the addition of 5 micrograms of iodide per gram of protein of this soy milk prevents any enlargement of the thyroid gland in the rat.

The presence of a true goitrogen in the raw soybean has not, as yet, been demonstrated by isolation and characterization. Although the lack of iodine is the principal cause of soybean goiter, raw soybeans, which contain slightly more iodine than heated solvent-extracted soy flour, produce greater thyroid hypertrophy (Table 4). This observation suggests that raw soybeans have goitrogenic activity, which is removed or destroyed during processing.

Table 4.--The effect of raw soy and toasted, solvent-extracted soy flour on the thyroid gland of the rat

Protein source	Iodine content diet/100 g.	Wt. gain 6 weeks	Thyroid wt./ 100 g. body wt.	Iodo-tyrosine iodine/g. thyroid
	Mcg.	G.	Mg.	Mcg.
Raw soy, Lincoln	1.04	100	39	1.7
Soy flour, toasted	0.71	137	19	8.1

It is of interest to note that by the usual bioassay of soy, one may not detect an iodine deficiency because overall growth is not always affected, and thyroid glands are not usually examined. Note in Table 5 that the weight gain of rats on diets 1B and 5B did not differ, yet there is a marked difference in the iodide content of these diets and in the thyroid weights.

Also one is not able to detect any change in the weight of the thyroid gland or the body weight gain when the dietary iodine level is marginal. However, on a marginal iodine intake, the amounts of iodotyrosine iodine and iodothyronine iodine in the thyroid glands are lower than on a higher iodine intake. This is shown in Table 6 where a soy milk with two levels of iodine was fed to rats.

The results of these studies indicate that in formulating soy milks or soy foods, serious consideration should be given to the inclusion of iodine.

Table 5.--The effect on iodine metabolism of the addition of KI to a diet based upon raw soybeans (7-week data)

Diet No.	1B	5B
Protein source	Lincoln soybeans	1B + 10 mcg. I/g. protein
Avg. wt. gain, grams	98.2	95.7
Thyroid wt., mg.	63.5	12.5
Iodotyrosine I/g. thyroid, mcg.	0.35	110
Iodothyronine I/g. thyroid, mcg.	.19	9.2
Ratio of iodine in iodotyrosines: Iodothyronine in the thyroid	1.8	11.9

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Table 6.--Effect of addition of KI to a commercial soy milk on weight gain, thyroid gland and iodoamino acids in the thyroid gland

Protein source	Iodine content of diet/100 g.	Wt. gain, 6 weeks	Thyroid wt. 100 g. body wt.	Iodo-tyrosine iodine/g. thyroid	Iodo-thyronine iodine/g. thyroid
	Mcg.	G.	Mg.	Mcg.	Mcg.
Soy milk, iodized level one	40	139	7	106	32
Soy milk, iodized level two	186	139	7	196	82

Amino Acid Supplementation of Soy Milk

There has been and probably still exists an impression among some members of the medical group, that the proteins of soy are not nutritionally adequate. In 1956, we published work (8) showing that rats fed a diet consisting of only a soy milk (plus vitamins and iron supplementation) permitted excellent growth, reproduction and lactation

for at least three generations. Under the experimental conditions,* this soy milk formula was entirely adequate as a sole source of fats, calories, minerals, and unidentified nutrients, as well as protein.

The advent of the availability of the amino acid lysine to the medical profession, led some physicians to add lysine to soy formulas (and cow's milk formulas). The impression was that lysine would improve the biological value of the soy protein. This practice prompted us to study the effect of supplementing a soy milk with lysine, methionine, and cystine, singly and in various combinations (9). As would be expected, we found that the addition of the sulfur-bearing amino acids up to 0.3 to 0.4 percent of the protein improved the nutritive value of the protein (Table 7). The addition of lysine, either alone or combined with the S-amino acids did not improve the rate of growth or protein efficiency of the diet (Table 8). In fact, lysine added at approximately 1 percent of the protein, appeared to suppress growth.

Table 7.--Effect of adding various levels of cystine or methionine on protein efficiency of soy milk for the rat

Supplement	Percent of protein	Two-week wt. gain	Protein efficiency 1/ 2 weeks
		G.	
None		19.5	1.97
Cystine	0.32	33.0	2.47
Cystine	.48	31.7	2.71
Methionine	.32	29.8	2.55
Methionine	.40	35.5	2.77

1/ Protein fed at 10 percent level.

The slight deficiency in the sulfur amino acid content of soybean proteins is well known and was postulated (cf. 8 and 9) to be of no consequence in practical infant feeding. This has been demonstrated since by Foman (10) and Kay _et al._ (11). As Mendel pointed out years ago, optimal growth and well being can be achieved by supplying a larger quantity of a nutritionally inferior protein provided the inferior protein does not show any marked deficiency of an essential

* NOTE: Iodides were not added to the diet, but no effort was made to achieve an iodine-free diet. Any goitrogenic effect of the soy milk was not apparent in these studies. Although thyroid glands were not examined it is possible that these rats may have had enlarged thyroid glands.

Table 8.--Effect of adding increased levels of lysine and sulfur amino acids on protein efficiency of soy milk for the rat

Protein efficiency for 2 weeks 1/			
Lysine as % of protein	Sulfur amino acids as % of protein		
	0.0	0.16	0.32
0.0	1.93	2.28	2.60
.24	1.94	2.14	2.56
.95	1.79	2.14	2.49

1/ Protein fed at 10 percent level.

amino acid (ref. 8). If one were concerned with feeding an infant the least amount of either milk or soy protein, then it would be necessary to supply approximately 11 percent more of the soy proteins than milk proteins to achieve the same rate of growth. The soy milks marketed in this country for infant feeding are not fortified with methionine.

U. S. infant feeding practices and the current protein level of soy milks result in a relatively high level of protein per kilogram of body weight. Consequently, as mentioned earlier, and as shown by practical clinical experience, no real problem exists. Methionine also imparts an unpleasant odor to soy milk. Although the odor can be masked artificially, this is not desirable because of the extensive usage of soy milks by allergic and hypersensitive individuals.

Summary

Several technological and nutritional problems occur in formulating and processing soy milk. It is suggested that soy milks or soy foods need the addition of iodine since there is an iodine deficiency in heated soy.

The amino acid supplementation of soy milk is not required provided the protein level consumed is adequate.

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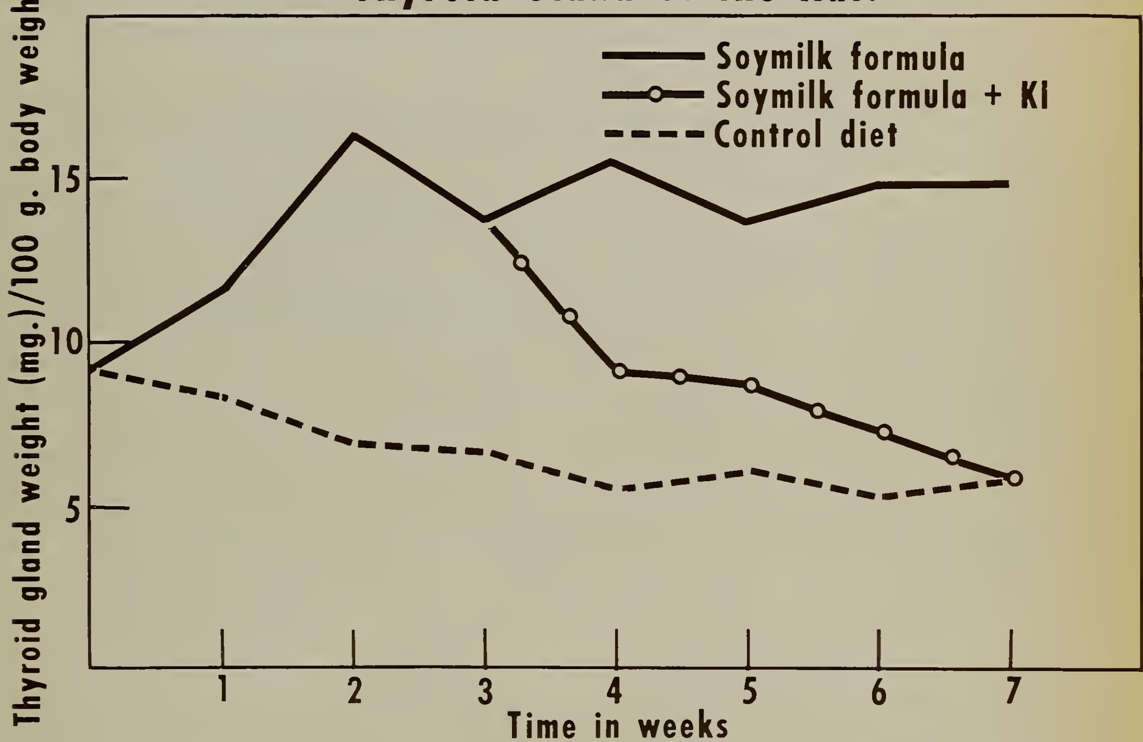

Figure 1.

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NITROGEN BALANCE STUDIES WITH NORMAL INFANTS FED SOYA BEAN PROTEIN

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Nitrogen balance studies reported from the Metabolic Unit of the State University of Iowa during the past few years have included investigations with normal full-term infants receiving approximately 7 percent of the calories as protein from human milk (1, 2), cow milk (3), or soya bean (4). A review of results with soya bean protein is presented here and interpreted in the perspective provided by the other studies.

Review of Studies

Because of the uncertainty concerning the ability of soya bean protein to support nitrogen retention adequately when supplying only 7 percent of the calories, a preliminary study (5) was carried out with infants receiving 41 to 45 percent of the protein intake from the soya bean and the remainder from human milk or cow milk. Four normal infants between 4 and 8-1/2 months of age received soya bean protein supplied as an infant strained food fortified during processing with DL-methionine and L-cystein. This product has been described in detail and studied with respect to acceptability by Barnes (6).

As demonstrated in Figure 1, intakes of protein by infants ingesting the soya bean food varied from 1.4 to 2.3 g./kg./day. It may be seen from the figure that the study failed to demonstrate superiority in retention of nitrogen with feeding regimens that provided all, or nearly all, of the protein in the form of human milk or cow milk over the regimen that provided 41 to 45 percent of the protein from the fortified soya bean food.

Four normal infants ranging in age from 113 to 154 days at the beginning of the study were then fed an experimental soya bean formula as the sole source of energy for periods ranging from 36 to 72 days. This formula provided 7 percent of the calories as protein derived from soya extract made from full fat flour from the whole bean. It was not fortified with amino acids. Additional vitamins, including 5 mg. of niacinamide daily, were administered.

The mean rate of gain in weight during the interval when the soya bean formula served as the sole source of energy was 21.3 g./day, a value nearly identical to that of infants of similar age receiving pooled human milk ad libitum. Intakes of protein (Figure 2) ranged from 1.3 to 2.0 g./kg./day with the exception of one metabolic balance period (intake 2.5 g./kg./day at 118 days of age). Intakes

were generally somewhat greater than those of infants of similar age fed pooled human milk. As may be seen from Figure 3, retentions of nitrogen were also somewhat greater by infants fed the soya bean formula than by infants fed pooled human milk.

Figure 4 presents the relation of retention of nitrogen to intake of nitrogen in studies with infants fed pooled human milk, those fed the soya bean formula and those fed a formula providing 7 percent of the calories as protein from cow milk. Since only one balance study was performed with the soya bean formula before 121 days of age and since the other feedings were not studied after 182 days of age, the data presented are limited to the age intervals, 121 to 150 days and 151 to 182 days. On the basis of this analysis, it is concluded that under the conditions of these studies, proteins from the three sources promote retention of nitrogen in similar manner.

Comment

Considerable caution is necessary in interpreting the failure of these studies to demonstrate differences in the quality of protein from human milk, cow milk, and soya bean. Adequate growth and retention of nitrogen are clearly only two of many possible criteria of nutritional adequacy. The reported observations with infants receiving the soya bean formula were of relatively short duration (1 to 2 months with each infant) and at an age (4 to 6-1/2 months) when the percentage requirement for protein in the diet may be considerably less than at earlier ages. Study of younger full-term infants or of premature infants, or reduction in protein content of the feedings (to 5 or 4 percent of the calories) might have demonstrated differences in protein quality. Longer periods of observation might also have disclosed differences. The requirement for tryptophan, presumably one of the limiting amino acids in the soya bean formula, may have been reduced by supplementation of the diet with niacinamide. Finally, it must be emphasized that the method of processing as well as the choice of other constituents of the soya bean formula employed in the study may have been particularly favorable with respect to infant nutrition. Soya bean protein processed in another manner or fed in conjunction with different types and amounts of carbohydrates, fats and minerals might have proved less effective in promoting retention of nitrogen.

In this connection it is of interest that DeMaeyer and Vanderborght (7) were able to demonstrate greater retention of nitrogen from protein of cow milk than from similar amounts of protein from soya bean in studies of 3- to 7-month-old African children recovering from kwashiorkor. It is possible that the metabolic performance of the subject recovering from kwashiorkor offers a particularly sensitive index of protein quality and therefore disclosed a difference that could not be demonstrated in studies of normal 4- to 6-1/2-month-old infants. On the other hand, it is possible that the processing of the formula was not completely satisfactory; as suggested by the

authors, cooking may have been insufficient to destroy the anti-enzyme factor. In a later publication (8) the authors state that some lots of the soya bean food promoted nitrogen retention to the same extent as did an equivalent intake of protein from cow milk.

Summary

Nitrogen balance studies with normal infants fed soya bean protein are presented and discussed. In studies in which approximately 7 percent of the calories were supplied as protein, the proteins of human milk, cow milk, and soya bean were found to have similar abilities to promote retention of nitrogen.

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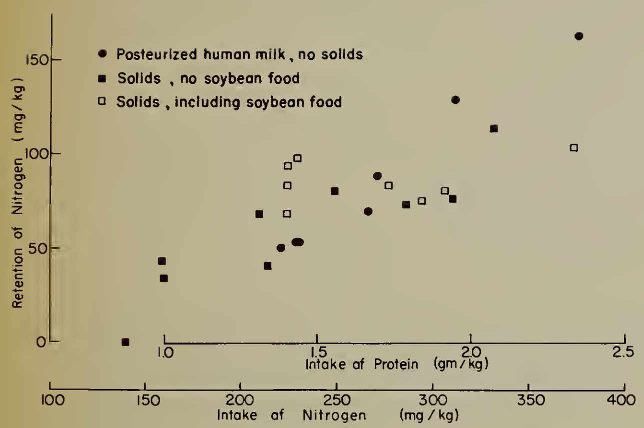

Figure 1.

Daily retention of nitrogen in relation to intake of nitrogen in studies with infants receiving the infant strained soya bean food or control diets. The intake of protein, calculated from the intake of nitrogen, is also shown. Each symbol indicates the mean daily retention of nitrogen during one 3-day balance study.

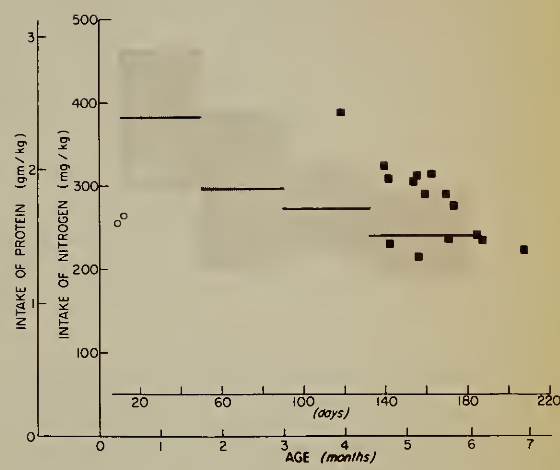

Figure 2.

Intake of nitrogen and calculated intake of protein during 15 metabolic balance studies with four infants fed a soya bean formula. The heavy horizontal lines indicate mean intakes of nitrogen of infants fed pasteurized human milk during the designated age intervals, and the stippled areas include two standard deviations above and below the means. Each solid square in the figure refers to the mean daily intake of nitrogen during the 3 days of a metabolic balance study.

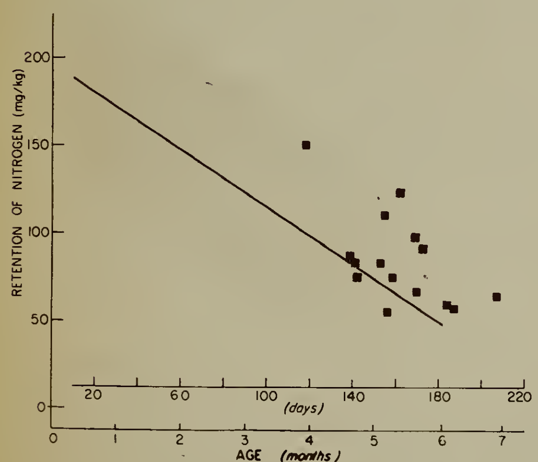

Figure 3.

Retention of nitrogen by four infants fed a soya bean formula. The heavy line depicts the calculated regression of retention of nitrogen on age for infants fed pasteurized human milk, and the stippled areas include two standard errors of the estimate of the regression equation above and below the regression line.

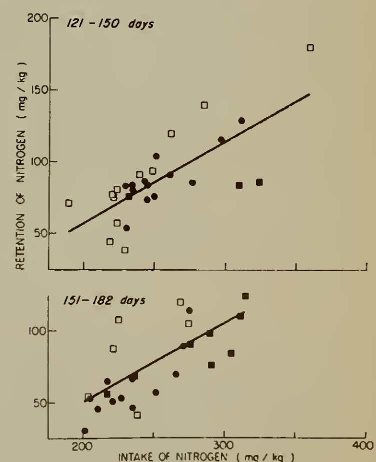

Figure 4.

Regressions of retention of nitrogen on intake of nitrogen for limited age ranges: 121 to 150 and 151 to 182 days. The regression lines are calculated from data pertaining to infants fed pooled human milk 1 (black dots) and formulas with protein from cow milk 3 (open squares) and soya bean 4 (solid squares).

FEEDING VALUE OF SOY MILKS FOR PREMATURE INFANTS*

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Soy milk is the name given to aqueous extracts from soybeans or to fine emulsions of soybean flour because of their milky appearance. Soybean milk has been used for a long time, probably over many centuries in a few Far Eastern countries, especially China and Japan. Its present principal use in the United States is infants with allergy (1) or intolerance (2) to cow's milk. More recently soya has been included in the "Protein-rich Food Program" of WHO, FAO, and UNICEF. This program is centered around the prevention of protein malnutrition, widespread in countries of the tropical belt, mainly among the preschool children. For all protein-rich foods included in the program, it is required that the recommendations of the Princeton Conference (3) held in 1955 under the sponsorship of FAO, WHO, and the Josiah Macy, Jr. Foundation are properly fulfilled. With regard to specifications and criteria for any given protein-rich food, WHO, FAO, and UNICEF act on recommendations of their joint "Protein Advisory Group." No product is accepted without chemical-analytical data, short- and long-term animal studies, acceptability tests, and extensive clinical studies.

Reproducibility of processed products with uniform chemical and biological characteristics is an important requirement. No significant deterioration on storage should occur under local conditions of the region where the product is destined to be used.

This procedure has been applied even to products which were already in use as food in human nutrition. Soya milk belongs into this category.

* These studies were supported in part by a grant of the Committee on Protein Malnutrition of the Food and Nutrition Board (NRC-NAS), by the International Nutrition Research Foundation (Arlington, California) and Mead Johnson Co. (Evansville, Indiana).

Our own studies encompassed a great variety of soya products, in addition to preparations of soya milk. On animals (rats), we have determined the "Protein Efficiency Ratio (PER) of these products, with 10 percent protein in the ration. The values for PER were calculated after a 4-week period, but the feeding was generally continued for 4 more weeks. As reference protein, we used a special preparation of "Low fat milk solids." Four different preparations of soya milk were assayed: Sobee (Mead Johnson), Mull-Soy (Borden Co.), Soyalac (Loma Linda Food Co.), and Saridele (from the factory in Djogjakarta, Indonesia). Sobee and Mull-Soy are prepared with soy flour, the two last-named products with aqueous extracts from whole cooked soya beans in the usual traditional manner (1). Saridele is a mixture of such spray-dried soya extract and sesame flour in a ratio of 4:1.

The PER-values obtained in one representative assay are given as follows:

	PER (after 4 weeks)
Reference skim milk..........	2.63
Sobee........................	2.20
Mull-Soy.....................	1.83
Soyalac......................	1.39
Saridele.....................	1.80

PER-values for Saridele showed in several assays fluctuations between 1.58 and 2.15. A large number of Toasted Soy flours from various producers showed uniformly high PER-values, between 2.0-2.4. The PER-values for the Reference Skim Milk showed only very slight variations, from 2.6 to 2.8.

For clinical studies we selected (a) Saridele (powder); (b) Sobee (liquid); (c) Soyalac (liquid and powder), and as control Lacbum (Mead Johnson), a proprietary cow's milk preparation. All formulae used had about 60-65 cal. per 100 ml. and the following crude composition:

	Protein	Carbohydrate	Fat
Saridele.............	2.0	6.5	4.0
Sobee................	3.2	7.7	2.6
Soyalac (liquid).....	2.0	6.5	4.0
Soyalac (powder).....	3.0	5.7	3.3
Lactum...............	2.7	7.8	2.8

With their prolonged stay in the Nursery and high growth rate, prematures born in our hospital offered the best material for clinical studies. Infants with birth weight 1,500-2,250 g. were selected. They were kept on the assigned formula (S_1 = Saridele powder; S_2 = Sobee liquid; S_3 = Soyalac powder or liquid) in the hospital on ad libitum feeding with the usual supplement of vitamins and from

the second month on iron (Syr. ferrous sulphate). After the infants have reached the weight of 2,500 g., they were discharged home on the same milk-formula they had received in the nursery. Since Saridele was not available in liquid form, for sake of convenience of the mother, the great majority of the infants who received Saridele in the hospital were put on liquid Soyalac at home and only a few were continued on powdered Saridele. The manufacturing process of the soya extract and the crude composition of Soyalac was practically identical with those for Saridele.

Infants received at home uncontrolled supplementary food. However, on regular repeat visits to the out-patient clinic, the mothers were given their special milk preparation in sufficient quantity and it may be safely assumed that the formula remained the same as it was in the nursery. The total observation period extended to 20-26 weeks. In the nursery, food intake was measured exactly and the Food Efficiency Ratio (FER = weight-gain in grams per 100 ml. of formula ingested) calculated. The caloric intake varied between 140-160 cal. per kg.

In the various groups of infants studied, weight and length increments were regularly recorded in the nursery and--after discharge--on their repeat visits in the clinic. Values for hematocrit, total serum protein, serum protein electrophoresis, BUN, Cholesterol, Ca and P (in the serum) have been repeatedly determined during the whole course of observation. Table 1 contains the relevant data for weight and length increments (expressed in percentage of average birth weight) and hematocrit.

The values for Food Efficiency Ratio (FER) were found for Saridele 4.9 (39);[1] Sobee 6.3 (25), Soyalac (powder) 4.6 (45), Lactum 6.6 (17). The differences between the values for Saridele and Soyalac on the one hand and those for Sobee and Lactum on the other are statistically significant.

The FER values are in remarkably good accord with the corresponding PER values obtained on rats. The same observation applies also to the weight-increments. Statistically significant difference was noticed in favor of S_2 compared with S_1 and S_3. In contrast no significant difference was found between the best soya milk preparation and the cow's milk formula. However, it should be borne in mind that S_1 and S_3 contained only 2 percent protein whereas S_3 had a higher protein content (3.2 percent). On the other hand, the differences in PER values could not be explained on this basis, since the tests were carried out with mixtures containing uniformly 10 percent protein.

The hematocrit values showed over the whole study-period no significant differences between the various groups of premature infants receiving soya milk preparations or cow's milk formula.

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[1] The figures in brackets denote number of observations.

Table 1

Diet	Data for	At 2 weeks	5	9	13	17	21	25
S_1, at home on S_3	Weight[1]	100(19)[2]	124(19)	156(19)	188(19)	217(15)	245(14)	260(8)
S_1 (throughout)	"	100(8)	145(8)	175(8)	201(15)	226(5)	288(5)	--
S_2	"	100(19)	136(19)	182(19)	221(19)	260(18)	300(13)	--
S_3	"	100(34)	124(34)	154(34)	189(34)	219(27)	252(22)	286(16)
C_1	"	100(46)	126(51)	182(51)	237(42)	264(29)	314(12)	362(11)
S_1, at home on S_3	Length[1]	100(15)	113(6)	113(11)	122(10)	130(9)	132(10)	140(6)
S_2	"	100(14)	--	116(16)	122(13)	126(11)	135(9)	139(6)
S_3	"	100(28)	111(24)	113(24)	122(24)	127(21)	133(19)	141(16)
C_1	"	100(44)	106(25)	125(50)	128(41)	134(31)	145(17)	151(12)
S_1, at home on S_3	Hematocrit	45(16)	35(19)	30(15)	33(17)	35(14)	35(12)	36(5)
S_2	"	47(11)	31(9)	32(8)	31(12)	35(10)	36(7)	34(5)
S_3	"	47(13)	35(20)	32(18)	33(16)	36(16)	36(15)	36(7)
C_1	"	44(23)	36(28)	29(27)	33(23)	33(22)	36(16)	35(11)

1/ The first values for weight and length are referred to those obtained at birth.

2/ The figures in brackets denote number of observations.

Table 2 summarizes the observations on morbidity of the infants in the study fed soya preparations in the nursery and later evaluated through visits to the clinic. Bulky, frequently loose stools were common occurrence, combined often with perianal dermatitis. Diarrhea was especially common with S_3, but almost exclusively only after discharge of the patients. With S_1 and S_2 only very few incidents of diarrhea were reported, again only at home. The high incident of "No Clinic Return" and "Failure to gain" was found predominantly in the S_3 group. With the exception of mild perianal dermatitis, no significant complications could be attributed to feeding with S_1 or S_2.

The periodically determined values for total Serum Protein (Fig. 1) confirmed the clinical observations on weight-gain and morbidity; statistically significant reduction of total serum protein values was observed in the groups receiving S_1 and S_3. Here we should recall that the infants in the group S_1 were put after their discharge home on liquid S_3. The reduced serum-protein values in the group S_1, especially after the first 8 weeks of observation may be attributed more to S_3 than to the S_1-feeding in the short preceding period (see also Table 1 regarding weight curve for this group). The differences between serum protein values in the group S_2 and C_1 were statistically not significant. In accordance with similar findings in the literature (1, 4, 5), the electrophoretic-globulin values showed in all groups steady reduction up to the third month of life and stabilization afterwards. No other significant changes were noticed in the electrophoretic pattern of the other serum protein fractions.

The curves for BUN values (Fig. 2) showed high initial figures for S_2 and relatively reduced figures for S_1 and S_3. After 4 weeks the values in all three groups showed similar fluctuations between 15-20 mg. percent. In infants on C_1, significantly elevated BUN figures were found up to 12 weeks of life. All these figures are higher than seen in premature infants receiving a cow's milk formula with 1.5 percent protein or human milk (6). It may be assumed that the high BUN figures recorded in the groups fed soya milk formulae and especially the group C_1 are related primarily to the high protein intake and reduced capacity of the kidneys of premature infants to concentrate.

Of special interest are the Serum-P figures (Fig. 3) in the groups receiving soya milk formulae compared with the control group C_1 (on cow's milk formula). The serum-P figures in the latter group were significantly higher than those in the Soya group. Premature infants seem to retain their originally high serum-P values longer than term infants (7). This is well demonstrated, even in an exaggerated fashion, by the figures obtained in the C_1 group. In contrast, the serum-P figures are lower in the infants receiving soya milk formulae. This might be explained by the lower P content and higher $\frac{Ca}{P}$ ratio in the soya milks compared with C_1 (0.04 and 0.05 P in S_1 and S_2 with $\frac{Ca}{P} = 2.0$ and 0.08 P in C_1 with $\frac{Ca}{P} = 1.25$).

Table 2

	Soybean morbidity							
	S_3			S_1		S_2		
	Nursery		Clinic[1]	Nursery	Clinic	Nursery	Clinic	
	Powd.	Liq.	Liquid					
Total cases	58	9	82	45	8	26	24	Total cases
Formula stopped	2	3	22		2			Formula stopped
Diarrhea		1	20		2		2	Diarrhea
Failure to gain		2	9		1		2	Failure to gain
Perianal dermatitis	1	3	25	12	3	10	3	Perianal dermatitis
No clinic return	11	3	12	5		1		No clinic return
Other illnesses		2	4	1	1		3	Other illnesses

1/ After discharge S_3 was given only in liquid form.

No significant difference was noticed in the behavior of serum Ca-levels throughout the whole observation period (Fig. 4). The fluctuations of serum-Ca values in the various groups were within normal range.

The serum cholesterol levels in the groups fed Soya-formulae were significantly lower, especially during the first 3 months of life, than those found in the C_1 group. The lowest serum cholesterol figures were observed in the S_3 group. This might be partly due to their generally reduced nutritional state. However, this does not apply to group S_2. The low cholesterol figures in this group might be related to the difference in the composition of fat, especially in the content of unsaturated fatty acids between S_2 and C_1. Similar findings and observations were made previously by Pomeranze (8) and Kay (1), with their respective coworkers.

Discussion and Conclusions

Biological evaluation of soya products, such as Soya-Milk, "toasted" low-fat and full-fat soy flour on animals (rats) confirmed the known fact that soya products properly processed may serve as satisfactory source of protein. The values for Protein Efficiency Ratio (PER) were found, however--even for the best and regularly reproducible toasted soy flour below that of reference low-fat cow's milk solids. We have several observations to show that soya products with added methionine (0.2-0.3 percent) have reached and, after further addition of vitamin B_{12}, have even surpassed the PER-values of the Reference Skim Milk.

In a recent study (9), no demonstrable difference was found in weight gain and N-retention of infants fed human milk and a special soya formula containing equal amount of N. These investigations, few in number, made on older infants and covering only a short period of observation should not obscure the fact that soya protein in its biological value is inferior to the protein in human milk or cow's milk.

In the present study, 4 different commercial soya preparations have shown PER values ranging from 1.4 to 2.1. Three of these preparations were given as sole and first formula (with supplements of vitamins and iron) to 80 premature infants during their whole stay in the nursery and also after their discharge home. Forty-six premature infants received as control a proprietary cow's milk formula (Lactum). The birth-weight of the premature infants in the study varied between 1,500-2,250 g. with balanced distribution in the groups receiving soya milk and cow's milk.

The soya milk with the highest PER (S_2) has promoted gain in weight, over the whole period of observation, comparable to that seen in the control group fed the cow's milk formula. Perianal dermatitis, in general mild, was the only frequent complication in the group fed

S_2. Diarrhea was uncommon. In contrast, infants receiving the two other brands of soya milk (S_1 and S_3)--with lower PER--have shown poorer gain in weight, compared with the groups receiving S_2 or cow's milk formula. Diarrhea was a frequent complication, especially after discharge at home.

No distinct difference in the figures for body length was noted in the various groups. In contrast, the serum-protein values were high in the groups receiving S_2 or cow's milk, and low in the groups fed S_1 or S_3. The -globulin values showed steady reduction up to the third month of life. No differences in hematocrit values were observed. The curves for BUN, serum-cholesterol and inorganic serum-P were in all groups receiving soya milk lower than in infants fed the cow's milk formula. The serum-Ca values showed uniform and statistically not significantly different patterns for all the groups over the whole period of observation.

In conclusion, commercially available soya products, and in particular soya milk may be used as a satisfactory source of protein for feeding young infants, even prematures. However, distinct differences are demonstrable in the nutritive value of such soya milk products not only on animals but also on infants. These differences must primarily be due to variations in the underlying technological processes. To name only a few possibilities, the use of aqueous extracts may eliminate some important protein fraction, which is left in residual fraction. Even more important seems to be the influence of exposure to heat in its intensity and/or duration. The present Conference is the forum of experts which is eminently qualified to give thought and lend assistance to this unsolved problem.

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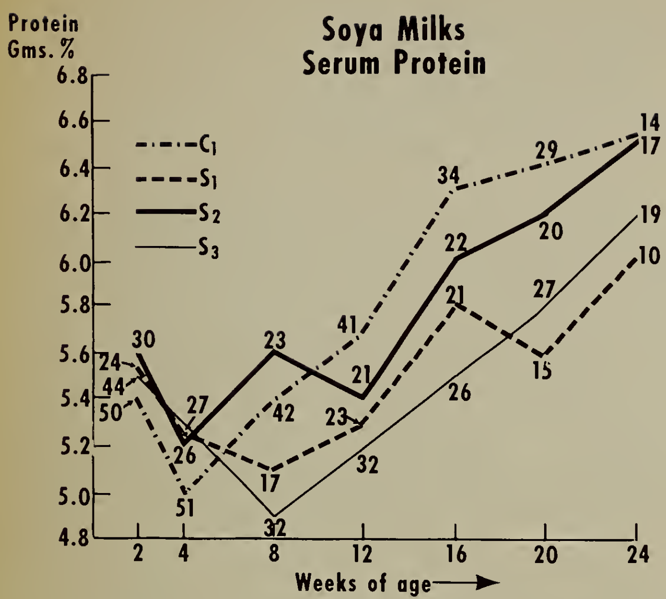

Figure 1.

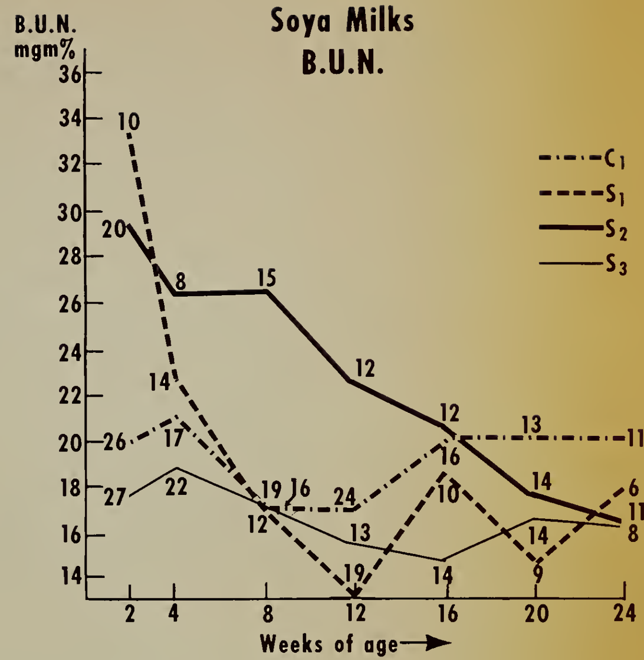

Figure 2.

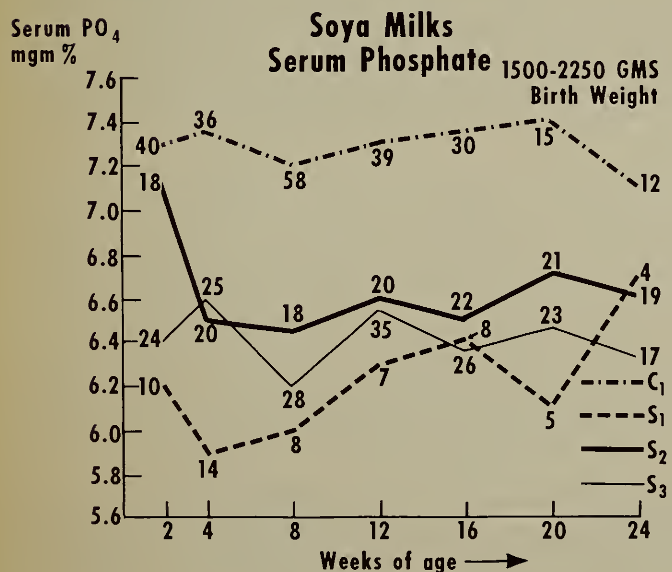

Figure 3.

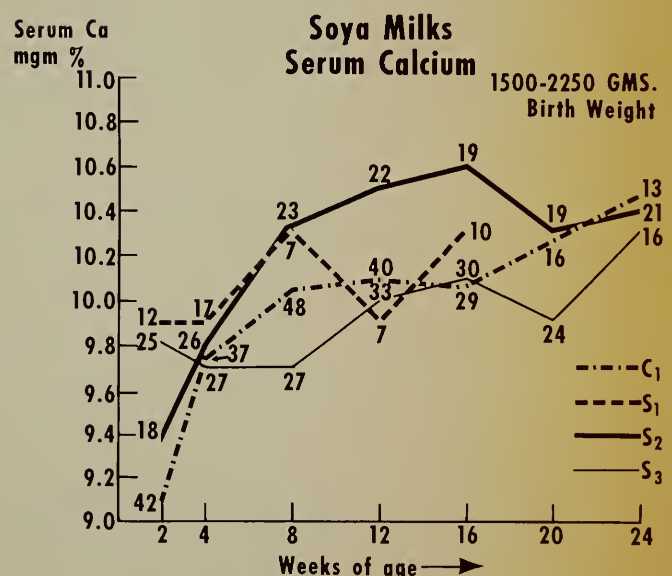

Figure 4.

PANEL DISCUSSION ON SOY MILK

Paul György, M.D., Panel Moderator

Panel Members:

Dr. David W. Anderson, Jr.
S. J. Fomon, M.D.
Dr. David B. Hand
Harry W. Miller, M.D.
Dr. H. P. Sarett

The discussions of papers presented in Session V - Processing and Feeding Value of Fluid and Dry Soy Milk were deferred until after the Panel Discussion since the panelists were those who had given the papers. The panel discussion was devoted in part to answers to questions raised from the floor. Since the panelists had no prepared talks the following comments briefly cover the salient points of their remarks. No attempt is made to report them verbatim; consequently, the statements attributed to the various speakers are based on unedited notes taken during the meeting.

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In introducing the panel discussion Dr. György said that FAO is writing a manual on milk and milk products. Several years ago FAO wrote a summary on milk. At the first two conferences 4 years ago there was considerable opposition to calling soy milk by that name. There is still opposition, but on the international level objections have subsided. Soy milk has taken its place along with human (or breast) milk, goat milk, and other milks which are normally designated to distinguish them from cow's milk.

Dr. Fomon commented that it is important that a study be made on a number of babies (30 or more) from birth up to 8-9 months of age. They have some opportunity to do this with students' babies. Controls are breast fed or fed pooled human milk. Dr. György said that for premature babies breast milk is not satisfactory. In the Orient most mothers nurse their babies as long as they can, 1 to 2 years, and a higher protein diet is needed for the older babies to prevent the occurrence of kwashiorkor.

Dr. Fomon expressed the opinion that for experimentation involving full-term babies the soy milk and human milk should be compared on an equal protein and fat basis.

In commenting on feeding of premature babies, Dr. György said that at relatively high levels of solids (up to 20 percent), differences were apparent between different soyas fed them. For experimental studies it would be best to fix the protein content and the total

solids. They use 12 percent solids. The addition of methionine improves the diet (for the rats). They would like to see rat studies extended to babies, using lower levels of protein properly supplemented.

Dr. Sarett said that in humans, methionine requirement may be less than it is in rats.

Concerning effect of protein level, Dr. Sarett mentioned that if one were to examine common pediatric feeding practices, which vary from 3.5 to 1.5 percent protein, the protein level fed is generally high. Most pediatricians feed at a level of 3.2 percent; this is in contrast to human milk which provides about 2.0 grams of protein per 100 ml. milk. Dr. Fomon expressed the opinion that it would be more useful to compare human milk with unfortified soy milk and see if fortification will improve it. On ad lib. feeding the protein intake is generally adequate. Dr. György commented that he would like to do it at 1.5 percent protein with and without methionine.

The question was raised as to whether plasma analysis could determine if amino acid supplementation was needed. No experimental evidence was cited on this point. Further discussion brought up the subject of flatulence. With regard to the latter effect, Dr. György said he has heard of no real problem in infants. He has observed loose bulky stools from soya, but it did not interfere with appetite and weight-gain. There is more cow's milk allergy trouble than soya trouble. There is no more diarrhea with soya than with cow's milk. Dr. Fomon said he believed that Dr. György has observed hypoprotein and edema in soy-fed babies. Dr. György's reply was only in babies suffering from severe eczema and loss of blood serum. Dr. Fomon then commented that he had only seen it in a baby fed Mull-Soy who also had cystic fibrosis of the pancreas. Another apparent case returned to normal when excess fat intake was returned to normal.

The question was raised as to whether we have data on the deleterious effect of crude fiber in infants, and possible limits. There is no real answer. Foods containing fiber are being introduced at an earlier age all the time. The question was also raised as to why we should use extracted soy flour and grits and why full-fat. Dr. Hand said that full-fat was frequently used in many areas where extracted soy products were not available. Dr. Sarett mentioned that Sobee is made from full-fat flour. In further discussion of soy flours, Dr. Anderson said that out of 14 soy flours looked at, 3 were satisfactory; the others were lumpy. They have trouble finding satisfactory full-fat flour. Mull-Soy (Borden Company) was formulated in close cooperation with 2 physicians. Specifications were for soybean oil as some allergic response has been reported from corn oil and sugars. Dr. Anderson asked Dr. Hand, "Why is fat higher in the extract than from whole soy preparations?" Dr. Hand in answer said that in the water extract the low-fat fraction is excluded.

Dr. Anderson asked the group what level of iodine should be recommended in a soy food. It would appear that this needs study with reference to the food used, total diet, and location in U. S. with reference to iodine-deficiency areas. We also need more study on iodo-amino acids, a very good method of studying this overall problem.

Following the statements by the panel members the meeting was opened for general discussion and questions.

The question was raised in regard to shipment of foods for mass feeding experiments as to how people in recipient countries are kept from feeding the products to pigs and chickens. In reply it was stated that under the program the law restricted exports to products designed for human food. Distribution is done insofar as possible through school lunch programs. The point to be brought out is not that the products supplied improve the weight gains and performance of children receiving them, since any improvement of inadequate diets will do this, but that recipient countries want to test for themselves the value and suitability of the food sent.

One case cited was a shipment of 1 ton of fish flour to Casablanca for use in a school feeding test. The odor was so bad one could hardly get close to the food, much less eat it. Upon being shown properly stabilized soy flour the bakers indicated they would be glad to use it in baked products. It would not stink up the kitchen and they could greatly improve the quality of the diet. The need is there; we have the product, but nobody takes any action.

There is an absolute need for work in each recipient country. There is a lack of encouragement of the processors to do the work themselves. It is most important to work through millers and food processors who are familiar with the food habits and problems of the country, and not in competition with them. There must be a complete follow-through of the product use in the recipient country.

For 4 years the Soybean Council of America has employed an oil technician who has held schools for oil processors in many countries receiving U.S. soybean oil. In India, for example, technicians held 4 schools to answer questions and show them how to hydrogenate soybean oil, and make good food products from it. Later the technician followed up problems discussed at the schools with visits to factories, showing them temperatures to use, how to handle the catalysts, something about hydrogen production, and all of the very special techniques and things that make for producing a good product. These things have been done with the manufacturers. Similar work was carried on with the protein manufacturers and further efforts are planned. In Israel the oilseed crushers pool are doing a similar job in areas where they are selling flour. We have had very good support with their people sending out technicians to do these same things. With all this work it is still not on the scale that is needed.

The question was raised as to whether there was a conflict of ideas in the emphasis by Dr. Smith on simplicity of the flowsheet for soy milk production whereas the flowsheet presented by Dr. Hand was quite complicated and involved. It was pointed out by Dr. Miller that several small plants, producing 200-400 gallons of soy milk per day, at an original cost of less than $2,000 each, can supply a small town. Dr. Van Veen indicated that there are different problems, depending on the product and country. What we would like to see is soy milk used in large-scale feeding programs as a number of countries have done with skim milk. In some cases the flowsheet of Dr. Hand will be more desirable, in others the simpler flowsheet.

If you send soy flour to big mills, they will put it in the flour they have been selling and the people will get the added nutritive value in their tortillas, chapatties, or other foods, and there is no problem. With small mills, who may not be equipped to handle it, there is more of a problem, and direct selling to consumers without regard to existing food channels can be even more troublesome.

Mr. Roach again brought up the fact that we must be careful not to usurp the place of milk or the name. Soy milk, properly defined and prepared, can fill a great need for an adequate supply of high quality protein in areas which milk cannot supply.

Session VI

PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS - PANEL DISCUSSION

Dr. James W. Hayward, Panel Moderator
Director of Nutrition
Soybean Council of America

PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS IN THE NEAR EAST AND INDIA

Fred H. Hafner

Director of Edible Protein Products Specialty Products Division
General Mills, Inc.

The Problem

On one side of our world lies a land mass called Asia on which is concentrated more than 50 percent of the total world population, over 1.5 billion people. Of these, India with its 420 millions and China with its 660 millions, account for 70 percent. This mass of humanity, which partly by choice, partly because of lack of understanding, and partly as a result of economic conditions, subsists on diets that are, by our standard, grossly deficient in various essential nutrients, particularly protein.

On the other side of our world lies a land mass called North America, occupied by only 7.5 percent of the total world population, or about 220 million people. Of these, the USA with its 180 millions accounts for over 80 percent. Here, where economic conditions are favorable, living standards high, and opportunities almost unlimited, there is an abundance of food--an abundance so great that by some it is considered burdensome.

The Problem? How to make food from our abundance available to countries like India, Pakistan, South East Asia, and the Near East in a form that is acceptable to the people; will meet their dietary needs; is priced so they can afford to buy it; and which can be marketed without disrupting markets for indigenous foods.

I have just stated what to me seems to be The Problem. Now let us look at some of the problems.

Problems at Our End

One of our principal problems is that we have been geared to a surplus disposal program rather than to an abundance utilization program. Up until this year, we, as a nation, have been more concerned with disposing of our surpluses of wheat, rice, soybean oil and nonfat milk solids than in supplying developing countries with the precise foods they require to help overcome nutritional deficiencies in their diets. Now, for the first time, consideration is being given by our Government to making foods available that will meet the specific nutrient needs of a developing country.

Selection of Foods a Problem

This gives rise to another problem: "What kind of food or combination of foods can best meet the dietary needs of a given country and would be acceptable to the people?" Once this has been determined by nutritionists familiar with the dietary regimen of a country, food technologists can go to work developing such foods or food mixtures for evaluation by dieticians. But all this takes time and since our Government wishes to move rapidly, particularly in Latin America, more expedient procedures are desirable. Hence the urgency for a "crash program" which needs to be undertaken immediately. However, there are more problem areas to examine before we turn to possible solutions or formulation of a program.

Indigenous Foods

I have heard frequent mention during this conference to the need for producing indigenous foods in the development countries. Although I am sympathetic to this approach which is strongly advocated by FAO in its Freedom from Hunger Campaign, nevertheless I personally feel this must be the long-range approach to The Problem and not the short-range approach; and even then, careful consideration should be given to the economics to make sure that indigenous production of foods is the practical solution.

Let me cite an example to illustrate my point. Ten years ago, Spain used very little soybean oil. Spain has large olive groves and olive oil is "king" there. The mere suggestion that Spain export its olive oil and purchase soybean oil from the U. S. seemed ridiculous to those who knew the eating habits of the Spanish people. Now, 10 years later, Spain is our largest off-shore buyer of soybean oil; Spanish people are using and, in many cases, preferring soybean oil as a food oil; and Spanish olive oil is being exported at a price considerably above its replacement cost as soybean oil. As a result, Spain has a net export income that is much greater than if they continued to utilize their olive oil production in Spain.

In view of this example involving edible oils, I am inclined to believe the same may be true of indigenous protein production, particularly in the case of deodorized edible fish flours which, if made properly, could be quite costly.

Short-Sightedness

Another problem area involving soy protein foods specifically relates to Public Law 480 and the absence of soy flour, soy grits, soybean meal, and even soybeans from the list of surplus commodities eligible for purchase by soft-currency or dollar-poor countries. In the case of soybeans and soybean products, only soybean oil has appeared on this list in recent years. Hence, countries, which have no dollars and must depend on P.L. 480 for purchases of American surplus

foods, have been unable to purchase soybeans and/or soybean protein products--even though they wanted to. During a 7-week assignment in India in 1959 for the Soybean Council of America at a Department of Commerce Small Industries Exhibit, I had occasion to meet with members of the Food Ministry at both state and central government levels to discuss soybean products. They were aware that soybean oil was available to them under P.L. 480 but they could not understand why soy protein products were not. I explained to them as best I could the reasons why soy protein products were not available under P.L. 480 but, as you can well imagine, they were not impressed. Yet I had the strong conviction at that time that soy protein products for human consumption, through some appropriate provision by Government, should be made available in limited quantities for market development work in developing countries that lacked dollars to make payment. Such a provision, if made 2 years in advance of our current 720 million bushel soybean crop, would have found the Soybean Industry ready to market soy protein products in such countries, and the total amount of soy protein products utilized in such market development work never would have been missed by us.

So much for our problems. These are the major ones.

Problems Abroad

I have already referred to the lack of hard currency in Asiatic countries as a deterrent to trade except in those items on the P.L. 480 list of surplus commodities. Soy proteins are not on this list.

Another problem of equally serious nature involves disruption of normal marketing practices where our exports are in direct competition with foods produced by developing countries. This creates not only ill will toward the U. S. on the part of the offended country but also a loss of income (usually as a result of a sharp break in the price of the competing indigenous product). For example: Heavy shipments of wheat to India from the U. S. under P.L. 480 resulted in a drop in exports of rice to India from Burma. This was followed by a decline in the price that could be obtained for rice in Burma with a corresponding loss of revenue to Burmese merchants. We need to reread "How to make friends and influence people"--then apply it in our international trade practices.

Still another problem has to do with the distribution of foods in the recipient country--which, as those close to the program know, is beset with problems. Many times the foods we export are uncommon to the recipients--hence are rejected or not used. On other occasions, the foods are recognized to have special value (such as canned milk powder) and are sold in the black market to merchants in exchange for rice or some other common food. In a country like India, there is no guarantee that the wheat we sell them will be used for the intended purpose. Unless it is utilized for the purpose intended, the problem of helping to move our abundances into consuming channels in developing countries to help alleviate malnutrition is not being solved.

Then we have the problem of male supremacy, particularly in the Moslem areas of the world. Food given to a family oftentimes will be eaten by the father and his sons. Anything left over, which usually is little, is given to the wife and daughters. This creates a problem that is more serious than most people appreciate.

So much for problems abroad. Again I have covered what to me seems to be the major ones.

Are there solutions for these and the others I have cited? I believe there are--though we may have to modify our approach if we hope to accomplish much in the way of improving the diets in developing countries and accelerate our program if we hope to make significant progress in the next 12 months.

Suggested Solutions

Here then are some things that could be done.

1. Utilize P.L. 480 funds available in dollar-poor areas to make grants to qualified research institutes, universities, technological schools, and food establishments (Annapurna in India); supply them with the types of foods we can make available, such as wheat, semolina, flour, soy flour, soy grits, bulgar, nonfat milk powder; commission them with responsibility for developing foods that are nutritionally designed to meet dietary needs of and have appetite appeal to the indigenous population.

2. Offer trials--shipments of various foods and food mixtures to developing countries, such as:

    a. Bulgar: Toasted soy grit blend (20 percent protein minimum).
    b. Soy Beverage Powder made from toasted soy flour, whey powder, dicalcium phosphate, lecithin, vitamin A, riboflavin, and possibly potassium iodide to simulate 2 percent fat content fluid milk when reconstituted with water.
    c. Semolina: Toasted soy grit blend (20 percent protein minimum).
    d. Strong (high gluten) flour: Soy flour blend for bread.
    Send a technician from the industry involved (Wheat Industry, Soy Industry) to each country receiving a trial shipment so that the evaluation can be expedited and properly conducted.

3. Place soy flour and soy grits on the P.L. 480 list (for export for human consumption only) so that blends of soy protein products or the products themselves can be provided in reasonable quantities to those countries deserving to use them (such as Egypt) but lacking dollars to make purchase.

4. Set up Research at appropriate Regional Laboratories to work on the direct utilization of surplus commodities in foods of developing countries which lack research facilities and food

technologists. This may necessitate bringing food specialists from the various developing countries to the U. S. to assist in the development of acceptable (not necessarily traditional) foods.

5. Encourage large-scale feeding demonstrations of new foods to children in schools in developing countries to obtain acceptability data.

6. Concentrate on providing improved nutrition to infants, preschool children, school children, and mothers.

7. Discontinue the practice of shipping foods to developing countries merely for the sake of reducing our surplus; replace it with a program keyed to nutritional needs instead.

There are problems no Government agency alone can solve, but it can help. These are problems the Soybean Industry alone cannot solve, but it can help. These are problems that research men, nutritionists, biochemists, food technologists alone cannot solve, but they can help. These are problems the Soybean Council of America alone cannot solve, but it can help. These are problems that UNICEF/FAO alone cannot solve, but they can help. This is a problem that home economists and dieticians cannot solve, but they can help. These are problems even the country involved alone cannot solve, but it can help.

To solve the paradoxical situation of a world suffering from some form of malnutrition while America copes with its abundant harvests, we need a program of cooperation among qualified agencies, organizations, associations, and technical personnel--plus our best public relation and marketing efforts. Speaking in behalf of the Soybean Industry, I can say without hesitation that we are ready and willing to cooperate to the full extent necessary.

PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS IN JAPAN

Mr. Shizuka Hayashi

Managing Director, Japanese American Soybean Institute

I want to first review how soybeans are utilized in Japan. The domestic production of 400,000 tons is used for foods. From approximately 1 million tons of imported soybeans we produce 150,000 tons of oil and 700,000 tons of meal. The oil is used for (1) salad (which is highly refined and deodorized), (2) frying and cooking (semirefined), and (3) margarine and mayonnaise (very small quantity). The first two uses can be increased in parallel with the per capita increase in consumption of oil. Japanese oil consumption is the poorest among the world nations. We need to consume oil at more than five times the present quantity which we are now taking, to reach the level of the western countries. The target of daily per capita consumption of the Japanese government for 1961 is 12.5 grams or 9 percent increase over the previous year (Table 1).

Table 1.--Consumption of edible oils

Year	Per capita daily	Increase over previous year	Consumed by total population
	G.	%	M/T
1955	7.52		259,350
1956	8.21	9.18	288,250
1957	8.66	5.48	306,066
1958	9.31	7.50	335,071
1959	10.52	12.99	380,414
1960	11.52	9.32	413,870
1961	12.50 (target)		470,440

Now what are the sources supplying this total of 12.5 grams? The list showing the breakdown is given in Table 2.

Soybean oil supplies about 30 percent of the total oil supply. Why has not soybean oil been consumed in a larger quantity and what will be the future? Problem No. 1 is the price and No. 2 is the quality.

Price:

The high price of soybean oil within Japan has checked expansion and limited its sales to the minimum. This can be applied to the explanation also in the case of margarine production which only uses

Table 2.--Oil consumption classified by kind
(Source: Food Agency)

	Soybean oil	Rapeseed oil	Other oils	Total
	M/T	M/T	M/T	M/T
1955	74,010	95,180	89,654	258,844
1956	81,015	113,812	93,425	288,252
1957	92,883	107,906	105,299	306,088
1958	99,183	103,553	133,230	335,966
1959	101,973	112,238	170,477	384,688
1960 (target)	111,710	109,660	192,500	413,870
1961 (target)	135,370	104,870	230,200	470,440

about 5 percent of soybean oil. Under import restriction of soybeans, with limited allocation of dollar funds, processors have been availing upon the privilege and advantage of the allocated funds, thus marketing their limited supply of oil with a good profit. Liberalization of import of soybeans in the form of A.A. (automatic allocation of import funds) instituted as of July 1 under which soybeans are now being imported freely has brought a change in this situation. The price of soybean oil will follow the trend of the world market. If the price of Japanese domestic soybean oil is raised unreasonably high by the oil crushing industry this may lead to a move for liberalization of soybean oil. In any case promotion is more effective with lower price of soybean oil. The factor involved in the future lower soybean oil price may have effect upon the status of miscellaneous oilseeds, which are being imported to supply 150,000 tons of oil. As shown in Table 3, the oil imports total 294,000 tons and domestic production 176,000 tons.

Quality:

The quality of soybean oil has been a question for many years. The reversion of soybean flavor in highly refined salad oil has been the most serious important factor against increase and expansion of soybean oil consumption. In Japan, salad oil is of more highly refined quality than that of frying oil. If the problem of this oil flavor reversion could be satisfactorily solved requirement for soybean oil will definitely be greatly increased.

It is surprising that a great many people in Japan still are not familiar with the soybean oil as being edible. In one of our oil promotion meetings the head of a woman consumers association asked whether soybean oil was edible. Here is a problem. This suggests the necessity of continuous promotion and education which of course requires financial support.

Table 3.--Oils and fats supply program for fiscal 1961/62

Oilstuffs imports	Oil and fat equivalent (crude)
	M/T
Soybean and soybean oil	135,370
Rapeseeds and rapeseed oil	11,100
Mustard and mustard oil	830
Copra and coconut oil	14,670
Cottonseeds and cottonseed oil	18,050
Safflowers and safflower oil	15,700
Palm kernels and palm kernel oil	5,910
Kapok and kapok oil	3,600
Sesame and sesame oil	6,890
Peanuts and peanut oil	100
Beef tallow	25,150
Lard	13,000
Hog grease	30,490
Cottonseed salad oil	2,500
Palm oil	4,190
Olive oil	30
Others	6,750
Total	294,330
Domestic production	
Rapeseeds	97,770
Rice bran	30,800
Whale oil	17,120
Fish oil	27,590
Hog grease	6,330
Others	500
Total	176,110
Grand total	470,440

Margarine and Shortening

Margarine and shortening produced in Japan (Table 4) are made from various oils including coconut, palm kernel, palm, cottonseed, rice bran, kapok oils, and beef tallow. Beef tallow with fish and whale oil are used in the biggest percentage. Soybean oil occupies only 0.6 percent. If price level of soybean oil is lowered the percentage of bean oil will be increased. This field needs exploration.

Table 4.--Consumption of oilstuffs for manufacture of margarine and shortening in January-December 1960

(Source: Food Agency Oil-Fat Division)

Oilstuffs	M/T	Share in total consumption
		%
Soybean oil	497.496	0.6
Rapeseed oil	37.890	
Cottonseed oil	2,597.381	3.2
Coconut oil	6,422.906	8.0
Palm oil	2,086.142	2.5
Palm kernel oil	2,746,174	3.5
Kapok oil	2,577.116	3.2
Safflower oil	279.664	
Rice bran oil	1,771.626	2.2
Other vegetable oils	916.357	
Whale oil	8,070.510	10.0
Fish oil	28,606.934	35.8
Beef tallow	20,349.926	25.4
Hog grease	2,757.961	3.5
Other animal oils	260.695	
Reclaimed oils and others	616.535	
	80,595.313	
Animal oils		75%
Vegetable oils		25%

Mayonnaise

Oil flavor reversion has been for many years the main objection which has checked the usage of soybean oil; SO MUCH WITH OIL.

Miso, Shoyu, Tofu

Soybean products for human foods in Japan are normally based on fermented soybeans or water-extracted protein. Shoyu, a soy sauce, is used for cooking foods as well as a table condiment. Miso is a fermented soybean paste used in making miso soup and in various ways of Japanese style cooking with vegetables, meat, or fish. Tofu is produced by coagulating soybean milk and is used in both Japanese and Western style cooking seasoned with shoyu. It is also put into miso soup or eaten in fried form. Frozen dried tofu can be stored for any length of time. These are just a few of the Japanese food products derived from soybeans.

Compositions of these soy products:

	Percent
Shoyu	
Protein	9-9.50
Salt (about)	18
Water (about	61
Carbohydrates	
Glucose	3-5
Dextrin	0.9-1.3
Ash	20
Miso	
Protein	10-12
Fat	5-6-1/2
Water	50
Starch, dextrin, etc.	3-6
Glucose	10
Ash	8-12
Tofu	
Protein	6-8
Fat	3-4
Moisture	88-90
Frozen Dried Tofu	
Protein	48.5
Fat	28.5
Ash	1.5
Carbohydrates	2.3
Moisture	15

These traditional foods like Miso, Tofu, Kinako, Natto, and Shoyu have remained unchanged for many, many decades. There has been, however, some progress or change in some foods.

Dried, powdered miso in instant form is now available. Due to convenience in handling and in storing, and suitability for export transportation, its consumption may increase.

Shoyu for many years before the war had been dependent upon 100 percent whole soybeans but now soybean meal has become the principal raw material. This is quite a change. A certain quantity of soybean meal is now used in the manufacture of miso and tofu. It may develop, in future, that perhaps miso and even tofu will be using 100 percent soybean meal. Import of soybean meal may then become

the subject of permanent "free import." The traditional methods of producing miso need to be reviewed for a fundamental change. The long period of time required for fermentation is a problem.

The fact that for many years consumption of miso has been on a level line or even tending downward suggests the need for a serious analysis of the situation. Of course QUALITY of tofu and miso, especially of tofu when 100 percent meal is used will naturally become the subject of research.

Consumption of shoyu will greatly increase if it becomes universally popular among the people of Western countries. I suggest that you leaders and experts in all communities who are here to discuss problems start using shoyu right now, and awaken the interest of the whole world. I have heard of a research result that salt when taken in crystal form can cause cancer, but not when it is dissolved in water. The best way to take salt will then be in the form of shoyu. Sea water contains only 3.5 percent salt but it tastes so salty that you will not want to drink. Shoyu contains 18 percent salt but you can take it without feeling the strong salty taste. I would choose shoyu.

Soybean Meal (Protein for Instant Food

Time may come when tofu may be readily made by every household. This will be a revolution but it will be a contribution to increased consumption of tofu. Research in this respect is not completed.

Soy Flour

Japan uses 2,230,601 tons of wheat flour in bread, spaghetti, noodles, and others. Some tests have been carried out to use 10 percent soy flour in all these foods, so far with success. More tests are needed and strong and continuous promotion towards school lunch authorities and bakers is necessary. This requires patience and financial support. Soy flour is now also used by ice cream makers.

Soy Milk

A few plants have been erected and bottled soy milk is now sold in the market in limited areas. A certain culture is used to eliminate the beany flavor. Quality has improved but to make it popular throughout Japan it needs more research, education, and promotion.

Frozen Tofu

Why should frozen tofu be food only for the people in Japan? There should be demand abroad if recipes adaptable to Western people are worked out. Production of frozen tofu even in the United States could be possible and profitable.

Food Sources of Japan

A general survey of the sood sources of the Japanese people shown in Table 5 indicates the relative position of soybean products in the economy. Soybean products represent about 4.5 percent of the total food, but they supply about 16 percent of the protein and 28 percent of the fat in the diet.

Table 5.--Food sources of Japanese people

(Including imports)

	Production 1,000 tons	Protein per day, grams	Fat per day, grams
Cereals			
Rice	12,500	19.7	2.4
Wheat, Barley, Oats	3,700	11.2	1.9
Others	1,350		
Meat	544	2.9	0.8
Egg and milk	2,210	3.0	2.9
Fish	5,544	12.0	3.0
Vegetables	8,360	3.3	0
Others		5.0	1.8
Soybean and soybean products (including miso, tofu, and shoyu)	1,500*	10.6	3.4 } 7.6
Soybean oil	150		4.2
Other fats and oils	204		6.3
Total	36,162	67.7	26.7
Average (1934-38)		54.9	13.2

* Total quantity of soybeans.

PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS IN EUROPE

Howard L. Roach

President, Soybean Council of America

Continental Europe and the United Kingdom are sophisticated markets that buy many of their food products partially processed and therefore the problems that the Council has been called upon to solve are different than the problems found in many other areas of the world.

Nearly all of the people of Europe are literate and have become familiar with the impact of advertising through the medium of the press, radio, and now television; and therefore these mediums of mass communication may be fully used to tell a story to the people.

The scientific knowledge of the people of Europe is equal to our own, therefore the fundamentals of good nutrition are much easier to transmit than in Asia, the Middle East, South America, or Africa.

Europe has known about soybeans for many years. In 1650, Explorer Engbert Kaemfer of Lemgo, Germany, brought back to north Europe samples of soybeans which he obtained on an overland trip to Manchuria. These soybeans are still on display at Detmold, Germany. Trade with Manchuria for soybeans for processing was in existence prior to World War I. Some of the first soybeans I ever looked at, I saw at a processing plant in the Rhine Valley in 1918 where I was stationed with the U. S. Air Force Army of Occupation.

The people of Europe had an unpleasant experience with soy products for human food during and after World War II. One of the last acts of Hitler, just prior to plunging the world into war, was to buy and transport via the Trans-Siberian Railroad vast quantities of soybeans from Manchuria to Germany for a supply of edible oil and protein. A couple of years ago one German processor in Hamburg told me that negotiations were still in process for payment to his company for some of these beans. As soon as hostilities started and Hitler became ruler of the Balkans efforts were started to get the farmers of that area to grow soybeans.

As soon as Hitler became master of Europe the use of an inferior grade of soy flour was forced upon the occupied countries as well as Germany. No instructions were furnished the housewife how to use this product and as a result, many soggy, unpalatable dishes were concocted for which soy flour received the blame. Later when the Axis was defeated, we were called upon to feed a starving Europe; we added fuel to the fire by shipping large quantities of soy flour, not of the best quality, to feed these same people that had had their fill of soy.

The reason for reviewing this history is that we may have a perspective to help us design a market development project for soybeans and soybean products that will enable these products to occupy their proper place in the diets of the people of Europe.

I would like to illustrate the current European attitude toward soy flour by telling you about a press conference held in London last week, September 4.

There were present reporters and editors from the daily press, catering magazines, food processing magazines, and others that reach the mass food market. At the conclusion of the conference, I asked for questions and one reporter said, "You may not know that the general public thinks of soy in food as a substitute for the real thing. During the war sausage makers started using a little soy in sausage but the first thing we knew they were using a little meat. I can tell you that I don't like soy sausage. Why don't you change the name of the product and spare yourselves a lot of the pain of a re-education process?" My answer was that the name of the product was not a responsibility of the Council. The manufacturers name the product. The Council's task is to create a good image and a desire for soybeans and soybean products. This desire must be strong enough to produce sales when the order-taker arrives. At one time there was a similar opinion regarding soybean oil. This has been pretty well overcome.

In Europe the Council has used all of the programs enumerated by Mr. Strayer in his paper "Market Development on U. S. Soybeans and Soybean Products." In Europe the Council places special emphasis on the following:

1. Agricultural fairs. Here we show how Soybean Oil Meal can be of help to the farmers.

2. Food fairs. At these fairs we interest the caterers, hotel and restaurant executives and food manufacturers.

3. Establish good press relations with the reporters and editors of periodicals that reach the food industry.

4. Emphasize the adequate and constant supply of U. S. soybeand and soybean products. Never use the term "Surplus." Talk about our "Abundant" supplies. We have learned that bargain prices, offered periodically by Iron Curtain countries, are not as important to European manufacturers as being able to have access to a dependable supply of raw material to keep their plants in operation.

5. Keep plans adaptable to change. For example, in Spain, during a good olive oil year we devote our attention to helping the

farmer with his livestock problems. He is also a grower of olives. We keep the image of SOY before him. During a poor olive oil year we switch our attention to the olive oil trade. The olive oil and livestock farmer is still our friend.

6. Obtain endorsement and cooperation from individuals and organizations whose opinions are respected by the citizens of the various countries. This is done through the organization of seminars, meetings, and other means.

7. Occasionally do the spectacular that will keep the name Soy before the people. For example, next week there will be held in Santander, Spain, the first National Seminar on the proper nutrition of the Fighting Bull. Bull fighting, being a national sport, not only in Spain but in Latin America as well, has given the Council a good press in Spain and South America. The payoff is--better bull fights, more tourism, and a profit was had by all.

8. Sell the idea of good flavor. We do not believe that free people will buy good nutrition but will buy good flavor and that flavor must be in keeping with the local habits and taste.

9. Work through and with established food channels. This means we must show the businessman that it will be profitable to include our product. We illustrate what volume sales can do to a cash register as compared to fewer sales and higher margins.

10. Finally, we spend our time and effort with the people that make decisions regarding what will be included in the food for the nation. We council on advertising, packaging, and all of the items necessary for any businessman that wants to see his business grow.

In the pasta of Italy to the wienerschnitzel of Germany, the Council sees an opportunity to sell an ever-increasing amount of soy protein for use in human food made from soybeans grown in the USA.

PANEL DISCUSSION ON PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS - POSSIBLE CONTRIBUTION OF FAO

Dr. A. G. van Veen, Chief, Food Science and Technology
Food and Agriculture Organization

We are discussing in this panel the problems which we meet when we try to make people in developing or highly developed countries eat soybeans or other soy products, which are, or may become, to use the terminology of Mr. Roach, "abundance" foods. I have been asked to tell about what FAO thinks about soy foods in this connection; about "abundance" foods in general; and also what FAO eventually might undertake in this direction.

Now let me straighten two things out. The first thing is this: I have noticed in the last couple of days that many people think that FAO is just a group of people sitting in a big building in Rome, Italy, enjoying or not enjoying the weather, the food, and the wine, and that these people make up FAO and what FAO stands for. This is, of course, not the case. We get our directions for what to do in a general way from the members of FAO, the member governments. There are at the moment around 90 governments all over the world. They outline for us the FAO policies and programs, and we (the secretariat) have to follow up and implement.

The second question which has been asked these days is this: Is it true that FAO in general is in favor that countries produce, if possible, their own foods and in this case their own protein-rich foods? People who want to export may not like this principle too much, but as a matter of fact most countries which have to import and have a lack of foreign currency favor this idea. This certainly is one of the principles of FAO and I think it is a sound one.

The other day Mr. Sabin of UNICEF mentioned that about 2 years ago the U. S. supply of surplus skim milk used for child feeding in most "developing" countries was stopped. What happened after that looked like a disaster because no government knew, whether and if, the supplies would be resumed and how much would become available. It was very clear then that many governments never thought of trying to produce more protein-rich foods themselves for their own population, and the FAO Conference we had at that time was a rather tumultuous one. I think that you will agree with me, that each country should try and produce most of the essential foods it needs.

During the last year the situation has changed somewhat and I think you know about this. The UN Assembly about a year ago adopted a Resolution in which they agreed on the principle of distributing food surpluses to food-deficient people, wherever this was "needed," and it became clear very soon that if the UN and UN agencies had to

take action in this direction that a great part of the burden would have to come to the Food and Agriculture Organization. During the last year FAO has been working on the planning of these "surplus or abundance" food distribution programs and we are waiting for our next FAO Conference in November to see whether the Member Governments will agree on what has been proposed. Taking into account that the member governments who adopted this Resolution, in the UN, are the same as we have in FAO, there will be very little doubt that FAO will have to concentrate (with the help of other international organizations, such as UNICEF, and to a certain extent, WHO) on a "surplus utilization program."

One of the relative drawbacks of this program is certainly that most of these "surplus" commodities are cereals. In general, FAO would favor to include protein-rich foods in some way in the program. One way in which this can be done is, as has been discussed, by converting cereals either in the producing country into animal protein or in the "receiving" countries. It would be very welcome to FAO, and I would say advantageous to the world in general, if there would be simpler ways of including protein-rich foods, such as suitable soy products, in the program. Of course I have to make a certain reservation because the FAO Conference has not yet made an official decision on these proposals but I would say that FAO would be much in favor if soy products could be used on a larger scale in the world, especially in the "developing" countries where, as you have heard, most of the protein malnutrition occurs. If we agree that this will be desirable, then we have to see what can be done. We know that earlier attempts, after it was discovered that soybeans and soybean products had a high nutritive value, were not very successful.

As you heard from the Chairman, I have been living for a part of my life in Indonesia, where soybeans in a certain form are very popular, and have always been so. I have been following with interest what was done in other countries and, as you know, this was not a great success in general. I will not discuss, of course, here the problems in connection with <u>cultivation</u> of soybeans. I will also not discuss <u>economic</u> factors. You will agree with me that if people have a choice between the usual legumes they know, such as chickpeas and other pulses, and they then are offered soybeans (which in the beginning certainly would always be more expensive), they would stick to the beans and pulses they produce themselves for economic reasons alone.

There is another thing I would like to say. We have in the past (I mean we nutritionists), very often worked on the principle that if we have a product on which our white rats grow well, this should be good for people too. We have gone and told people that soybeans have a high nutritive value and that they have more protein than most pulses so they should try and eat them.

Well, as Mr. Roach said, very seldom people eat foods because of nutritive value. If one knows about "nutritive values" and at the same time the product has a good flavor and taste, well then that is fine. But in general the great difference between experimental animals (or at least white rats) and human beings is that human beings have taste preferences. Why they prefer one food and not another, that is a complicated story which we cannot discuss here. But we have to admit that soybeans as such, and I think I commented upon this the day before yesterday, are not very attractive. I know that two attempts were made in a country to make a group of people eat cooked soybeans for which they did not even have to pay. Because they did not have to pay they wanted to cooperate in the experiment, but the fact that the tissues of the soybean (unless chewed very well) give difficulties in digestion, and because of the not very acceptable bean flavor, the result was that these experiments had to be stopped.

Repeatedly there have been attempts to introduce certain processed soybean products from Southeast Asia in other countries with little success. For example, many years ago, I think 25 years ago, a group of missionaries from Travancore, a poor region in South India, wanted to make "tempeh" from soybeans (which you had yesterday and enjoyed). For 3 weeks we gave them short courses in how to make tempeh. When the missionaries went back to Travancore they made tempeh and it was fine, but the Indian population did not have any interest in this unknown fermentation product and the experiment failed.

After the war, as Dr. György knows, one of my former coworkers came to South Rhodesia, and saw a lot of soybeans exported, and not eaten by the population. He went to a local food technology institute, where the staff became interested. For some time the interested scientists made "tempeh" for the hospitals, but the population having no experience with fungus products at all (as the people in Southeast Asia have) just did not want to embark on tempeh manufacture and at the moment tempeh has disappeared from Rhodesia.

Experiences like this we have to take into account and I was very glad to note that at the moment much attention is given to things like consumer preferences.

I was particularly impressed by the talk of Mr. Strayer and I was also much impressed of what Dr. Hilbert told us about soy research in countries in the Near and Far East on locally acceptable products. This is a new approach and is quite different from what was done in the past; I think it is extremely promising.

Of course, if one can include defatted soy flour in wheat flour for making bread or chapatties, or in corn flour to make tortillas, and if this can be done in large mills I think there will not be much of an acceptability problem. However, if soy flour is introduced

in countries where there are a great number of small mills for corn or for wheat, one may have serious problems, such as those of distribution, and what do the small millers do with the soy flour they get? It may be they will use it for feeding of pigs or chickens, which of course is excellent from the point of view of getting rid of soy flour, but is not in line with the original intention.

I would like to say that one should not under-rate acceptability problems. Even after 15 years of wheat imports in Ceylon, most Ceylonese would like to get rid of this wheat because they prefer rice. Many times it has been tried to introduce parboiled rice, to "milled rice" eaters, in East and Southeast Asia but until now the results have been practically nil.

I would like to end up with stating that FAO in cooperation with UNICEF has started on promotion campaigns for protein-rich foods in a number of countries. I would like to mention for example Morocco for fish flour, and Senegal for certain products containing peanut flour. Our general experience is that introduction of new foods (or of old foods prepared in a new way) is a thing which has to be done carefully, otherwise the clock may be set back for many years.

PROBLEMS INVOLVED IN INCREASING WORLD-WIDE USE OF SOYBEAN PRODUCTS AS FOODS - TECHNICAL ASSISTANCE IN DEVELOPING SOYBEAN MARKETS

Allan K. Smith

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Most people, even those suffering from malnutrition, do not eat strange foods without persuasion. Soybeans and soybean products are strange to people in many countries. In countries familiar with soybeans like Japan, Korea, Taiwan, and other Oriental lands, there is a ready acceptance of their use in foods; in fact, they are an essential part of the diet.

The extensive use of soybeans by people in the Orient was developed in their monasteries and in their homes over a very long period of time and without the benefit of research as we know it today. Their use of soybeans was probably stimulated by the need for more protein and more flavor in a predominantly vegetarian diet. Meat-eating countries do not have serious flavor problems, whereas in vegetarian diets the flavor must be derived through addition of seasoning, by fermentation processes, and from protein hydrolyzates. Now we are proposing the introduction of soybeans into countries where their food and feed uses are unknown, and we cannot wait or depend on the ingenuity of the housewife, the authority of the local priests, or instruction by other local leaders to teach the people the value of soybeans and how to use them. In such countries the introduction of soybeans should be encouraged and accelerated by using modern methods, that is, by a continuing technical assistance program. A technical assistance program should also provide for teaching the housewives how to improve the health and vigor of their people through an improved diet.

The use of research for developing new food products should not be limited to countries having a high educational and economic standard but should be used in all countries where soybeans are to contribute to the diet of the people.

Perhaps the best example of the importance of utilization research is found in our own country in recent activities to extend the use of soybeans for food. Although soybeans have been grown here for 30 years, their use in foods over this period has grown very slowly. However, we do not expect the American housewife to develop new ways to use soybeans and soybean products. Every food processor knows that only through an extensive research program can we hope to develop a soybean food industry. Our food problems are now being solved through research by industry, state universities, private institutions, and Federal laboratories.

Another good example of the use of research in the United States is the tremendous expansion of our poultry industry. This unusual expansion was neither an accident nor a development of the farmer, but it was the result of nutritional research on improving the efficiency of poultry feeds. This same research has already been used in a limited way in expanding the poultry industry in some European countries, and the need for extending its use to other countries is apparent. Since research is sq essential in solving new problems for us, should we expect the newly developing countries to make substantial progress with their very limited technological resources?

I can further illustrate the need for technical assistance in an export program from some personal observations. One experience was during my visit to Tokyo in 1948. At that time the Japanese people were living on a diet of about 1,500 calories per day. To help improve their food supplies our government shipped to Japan substantial quantities of soy flour and corn meal. Both of these products are typically American and were strange to the Japanese diet and customs. Although soy flour sounds like a natural for Japan, its use there was unknown, and corn was looked upon as a feed for pigs. These foods, which were unfamiliar to Japanese food processors and to her people, were promptly placed in storage because proper information was lacking on how they should be used. Much pressure was necessary by our officials to get these products eventually into food channels.

I am sure many people attending this conference are familiar with the problems we had some years ago in attempting to introduce soy flour into bread in Greece. They will also recall the difficulties in Germany and the more recent problems in England, Japan, Colombia, and other countries.

In Colombia the law requires the addition of a small amount of soy flour to wheat flour. However, I have been informed by a reliable correspondent that although the wheat millers buy the soy flour as required by law, they do not add it to the wheat flour because baking problems have not been solved. The baking problems may reside in the quality of the soy flour, as well as the baking technique, but for either reason they need continuing technical assistance. Although these people would be greatly helped by a quality control guide, direct technical assistance in selection and use of soy flour is the best way to solve their problem.

Our Laboratory has answered literally hundreds of letters from countries all over the world requesting technical information on processing and use of soybean products for food. However, in appraising these efforts I am sure they have had little effect on increasing soybean utilization. The more letters I write the more I am convinced that developing soybean utilization in other countries through correspondence is a very slow and inefficient method.

If we want to accelerate our soybean export program we should be prepared to export our technical information through an organized exchange of technical personnel. We should send technical experts to the country to be served to make first-hand, practical observations of their food and feed problems so that definite research and development procedures can be recommended. This direct contact can be followed up by inviting technical trainees from the countries to be served to U. S. laboratories for training in special areas of food technology and basic research so that when they return home, these trained people are potential leaders in the development of new and improved foods for their country.

My foreign experience has been mostly in Japan, which is the easiest place in the world to sell soybeans for food. The Japanese Government recognizes the need of her people for more protein, and they have definite plans to take care of their requirements. Besides having their own well-developed method of using soybeans, they are much interested in our western-style foods and in our soybean technology. Part of their expanding use of soybeans is through adoption of our western-style products. Thus, Japan is importing our technology as well as our soybeans.

New approaches will be needed, however, for introducing soybeans in other countries. While certain basic foods and processing methods can be used anywhere, the variability of food customs and flavor requirements create separate problems for each country.

Baby Foods

Feeding babies is a special problem that presents fewer difficulties than feeding adults. A baby is satisfied with the simplest of foods so that our principal problem is the development of a low-cost, highly nutritious, protein-fat-emulsion or powder product which, when suspended in water, will pass through a nipple. These problems have been reviewed earlier during this conference.

Both liquid and dry products have their place in a baby food program, but I believe the lowest cost product will be a liquid milk produced in the area where it is to be used. Simple processing methods and simple equipment are important requirements. In many places labor costs would be very low; in fact, small units could be operated almost entirely by women.

From our present knowledge of soybean milk these requirements appear to be attainable. The tofu plant is an example of production of a very important food product in small-scale units. The tofu plant needs only slight modification to serve the dual purpose of making both milk and tofu. The nearly 50,000 tofu plants in Japan testify to the usefulness of this product in the diet of the Japanese people. The extension of the tofu plant to a dual operation in developing countries should be given serious consideration as a means of improving diet and for enlarging our export market for soybeans and soy products.

Session VII

COMMITTEE ON QUALITY AND PROCESSING GUIDE FOR EDIBLE SOY FLOUR AND GRITS

Dr. James W. Hayward, Chairman
Director of Nutrition
Soybean Council of America

PROGRESS REPORT OF COMMITTEE ON QUALITY AND PROCESSING GUIDE FOR EDIBLE SOY FLOUR AND SOY GRITS

Dr. James W. Hayward, Chairman

Director of Nutrition
Soybean Council of America

Committee Members

Mr. L. E. Allen, UNICEF
Dr. J. C. Cowan, Northern Utilization Research and Development Division
Mr. G. M. Diser, Archer-Daniels-Midland Company
Mr. F. H. Hafner, General Mills Inc.
Dr. Max Milner, UNICEF
Dr. A. K. Smith, Northern Utilization Research and Development Division
Mr. R. L. Terrill, Spencer Kellogg and Sons

This project was initiated back in August of 1960 by the Minneapolis office of the Soybean Council of America at the request of Dr. Max Milner, Senior Food Technologist, Food Conservation Division, UNICEF, New York, N. Y. The purpose intended for this guide was to establish quality standards for soy flour and soy grits that could be followed in producing these soya products in quantity for possible use as a major dietary source of protein for young children and/or a major source of supplementary protein in cereal-base and other types of foods for children and adults. This guide has also had as its purpose the matter of acquainting various people identified with WHO/FAO/UNICEF-assisted programs with the identity and many virtues of the particular soy flours and soy grits that are most likely to be used for the feeding programs as indicated.

The first rough draft of this guide was issued and circulated to members of the Protein Products Committee (Soybean Council of America, Inc.) on July 11, 1961.

This guide has now received initial clearance of the U. S. soy flour processors through the Protein Products Committee of our "Council," and it will be submitted presently in its corrected form to our Special Collaborative Committee which is identified with this project, as listed above.

This "guide," still tentative as it now stands, contains the following three distinctive sections:

1. General, with introduction, definitions, and types of soy flour and grits, descriptions and flow charts covering processing, composition, and recommended uses.

2. Analytical Methods--source of official and tentative procedures for many routine and special determinations are cited and in several instances specific procedures are enclosed with the guide. These procedures cover determination of general composition and methods under "quality control," such as urease activity, water dispersible protein, protein bioassays with laboratory animals; sanitary analyses, including bacteriological procedures, procedure for acid-insoluble ash and procedure for detecting presence of possible insect and rodent contamination. This portion also deals with packaging aspects.

3. This is a separate section containing product specifications for each type of soy flour and/or soy grits which are considered to have application in these feeding programs.

The soya products that are now covered by specifications are as follows:

Full-fat soy flour (general purpose)
Defatted soy flour (general purpose)
Defatted soy flour (toasted)
Defatted soy grits (general purpose)
Defatted soy grits (toasted)

Detailed information is supplied for each soya product, as mentioned, under the following categories:

DEFINITION

ANALYSES, including particle size

SPECIAL CONSIDERATIONS:
- I. Nutritional or Functional Aspects
  - PDI (protein dispersible index)
  - Urease Activity
- II. Sanitation Aspects
  - Bacteriology - total bacterial plate count
  - Acid-insoluble ash
  - Insect and rodent contamination

PHYSICAL PROPERTIES
- Color
- Odor
- Taste
- Texture

RECOMMENDED USES

Discussion Following Hayward Report on Processing Guide

Dr. Hilbert commented that one of the properties which appears to have been overlooked is storage life under specified conditions of temperature and time. He referred particularly to a case where canned food stored on the beaches in the sun in Egypt showed definite deterioration and created a very bad impression when it was fed to people and they became sick.

Mr. Hafner commented that storage life of soy flour is unusually long, far more stable than milk products, even at 140° F. if kept sealed. In polyethylene bags there has been no deterioration up to 5 years if kept dry and free from rodents and insects. The University of Minnesota has a relative humidity study, reprints of which are available.

In India after 7 weeks' storage at 90°-104° F. at a relative humidity well over 75 percent there was a slight softening and loss of crispness of samples stored in open bowls protected only by refrigerator covers at night, but no deterioration. This applied to both extracted and full-fat flours if the lipase had been destroyed. Until a few months ago no stable full-fat flour was being sold. Now we have stable products.

In paying tribute to Dr. Hayward and his committee, Dr. Milner indicated that the problem is half solved if it can be defined. This meeting and the Processing Guide have defined our problems and brought them into proper focus.

Session VIII

SUMMARY OF CONFERENCE

Dr. F. R. Senti, Presiding
Director, Northern Utilization Research and
Development Division

INTRODUCTION TO SUMMARIES

Dr. F. R. Senti

We have had excellent discussions on the many and diverse aspects of the problems on the use of soy products in human food. On behalf of the Northern Division as well as the other cosponsors--the Soybean Council of America, the Foreign Agricultural Service, and UNICEF--I want to thank the speakers, the panel members, and all the participants in this conference who have served to bring into focus the problems that exist in the use of soybean products in meeting worldwide nutritional needs for protein. But now, as we come to the end of this conference, I think it would be appropriate to briefly survey what we have said here in regard to the major aspects of the problem. Dr. Darby will summarize the nutritional deficiency problems that exist which vary widely from those of the economically underdeveloped countries to those in countries which have cash to pay for products. Mr. Roach will comment on the problem of acceptability of soy products by the peoples of these developing countries. Success in solving these marketing and promotion problems will control to a large extent the wider use of soy products. Finally, I will review the areas where further research can make worthwhile contributions.

V

SUMMARY REMARKS OF DR. W. J. DARBY ON NUTRITIONAL DEFICIENCY PROBLEMS

Before commenting on the conference, I should like very much, Dr. Senti, to express to you, the general chairman of this conference, to the sponsoring agencies, and to the Northern Regional Laboratory as our host, my appreciation and that of the other conferees for the opportunity of attending this stimulating and informative conference. I said at the first session that I knew very little about soya but I know much more about it today that I did approximately 48 hours ago when we started this meeting. This has been a unique gathering, the kind of meeting in which people with varied backgrounds and with a wide interest in foods and a particular interest in soya have exchanged ideas. It sets the pattern for what I hope will be future meetings in relationship not only to soya, but also to other useful or potentially valuable products. I think it would be impossible and unnecessarily repetitious to attempt to summarize all of the points which have been made relative to the medical problems of nutritional deficiencies or to the nutritional aspects of soya during this conference. Instead, I think that I might give two or three impressions which I have, then some comments on a few special points.

This meeting has emphasized and highlighted the value of, to paraphrase Lord Orr's comment of many years ago, the marriage of technology and nutrition. The meeting has clearly appraised the medical usefulness and quality of food products made from soya, particularly those for infant feeding. I am quite certain that as a result of some of the discussion here and the attention which this conference has called to these products, that many of those in use at the present time will be improved. The meeting has clearly pointed to the usefulness of (and I won't quibble over what we call it) the soy milk type of infant food. May I, however, comment about forms of infant foods. It has been pointed out in the meeting that we need to have foods that are adaptable for a variety of cultures. Despite this, this morning one of the speakers stated that an infant food had to pass through a nipple. I don't think this is true. There are many places in the world where infants are fed gruels or paps which are never put through a nipple, and in many parts of the world where we are interested in improving the feeding of infants the use of a nipple is a pretty unsanitary affair--unless it is the mother's.

The second point concerning infant foods was highlighted by Dr. Sebrell's presentation: To meet the world's need these foods must be cheap. This bears on one of the comments and some of the "schizoid" viewpoints which I believe we find in trying to deal with our American abundance, our industrial interests, and, at the same time, our desire to help those with less abundant resources. It is apparent that products which are made and manufactured at the cost

level for the American market are not going to meet the nutritional needs which are so appalling abroad. Regardless of whether it's going to make a lot of money for us or not, attention must be directed at producing economically feasible products for use abroad, either producing them or promoting the production of them in the country of use. I suspect that the latter is going to make the major contribution to health in the long run--i.e., promoting the production of the product in the country where it is needed.

The research findings summarized here have raised many questions and opened avenues for additional investigation. On the other hand as was stated this morning, it is important for us not to delay application of the knowledge which we now have. We can separate our consideration of needed research and application into about three categories based on the kind of products we are considering. First of all, the infant foods. Here we have the benefit of a great deal of research, but we need certain additional knowledge. Secondly, foods which we might call "supplementary" foods or modified products, such as the addition of protein-rich flour to bread. These have another type of medical consideration than do infant foods and it is obvious that here we don't need a great deal of additional medical or clinical research. Instead, we need promotional research, marketing research, marketing know-how, promotional know-how. Finally, a third type of product is the one which we would like to promote for household production or for a very small village or community manufacture. Here again we need two kinds of research--one, the medical evaluation of products in order to permit us to make proper recommendations concerning the nutritional usefulness, especially for the younger age groups (this is part of the work which the Protein Advisory Group is concerned with at the moment), and research into the best methods of production of a quality product.

It has been noted by several speakers that in each country it seems "desirable or necessary" to conduct field research in schools in order to prove that a product is good, is going to promote growth, development, and so on. I should like to make one cautionary statement about this. If you start out to make such a demonstration you're going to find it very difficult to get results that demonstrate what you think you're going to show. This is a lesson which has been learned by many. It sounds good in theory to say that if you go out and give a school meal containing soya milk, liquid milk, or whatever to children, they are going to grow and weigh more inside of 3 months or 6 months. It's just not that simple and doesn't work out like the book says it should. Practical considerations render such studies nonproductive in most instances. You have to take some of these things on faith. Now it is valuable, however, to have demonstration programs--and I should like to call these demonstrations and not see us confuse research with demonstrations. In these demonstrations we are showing how to use products and demonstrating the acceptability of them. Through the

demonstrations we are in position to dispel some of the accusations which later may be made as a result of accidental and nonrelated occurrence concurrent with the proper use of the products.

During the meeting there have been identified a number of toxic materials or principles of one sort or another which are associated with soya. The goitrogenic property is one of these. We recognize that a similar effect is a property of many foods--peanuts, kale, members of the Brassica family and so on. The zinc availability influence is another such effect. Incidentally, this may not be foreign to human interests. In our work in Cairo, at the moment Dr. Prasad is studying a group of children with retarded growth, anemia, and other characteristics who appear by certain tests to be deficient in zinc or else have some derangement of zinc metabolism. It is too early to interpret these findings, but I am pointing to them because they imply that the animal experiments alluded may eventually prove to have some significance for the human.

I'll not enumerate or comment on the other toxic materials except to note as one interested in the subject of food additives that it is rather intriguing that soya, a food product which the food faddists, the "natural food" and the "organic gardening" cults and others who take extreme stands against food processing, additives and agricultural chemicals, have so long held up as one of their ideal foods, should have many "toxic" properties which are improved by processing. If these were associated with something that man put in or created in processing the food would be subject to a vigorous attack by the "blood-thirsty penpushers." It is worthy of emphasis that by proper processing, which these same natural food cult people damn, one can improve soya so that it has great and unquestioned usefulness. This makes the irrational position of the faddist even more illogical.

I am impressed by the possibility of application of a great deal of the information which we have seen reviewed here to other similar foods, the beans and legumes generally. The widespread use and value of legumes in the diet makes this important. In other words, the research contributions which those interested in soya are making are often widely important because of the use of other beans, pulses, and legumes throughout the world and their value in meeting the problem of protein foodstuffs.

I wish to stress by repetition the need to keep in mind in the development of foods for meeting the problems of widespread nutritional deficiencies abroad, that the most urgent deficiencies are among the infant and preschool child group. This is where the slaughter by nutritional deficiency of half of those born occurs. Here is where the development of low cost, and I repeatedly emphasize low cost because it is essential if it is to be effective, that low cost, physiologically suitable products, and I underscore products in the pleural, which fit into the culture of the region will help relieve nutritional deficiencies. The improvement of

dietaries through the addition of protein to food for use by other age groups is beneficial when it can be done. However, the problem here is of a considerably different urgency, a considerably different magnitude medically, than is that of the need of the infant and preschool child.

SUMMARY REMARKS OF MR. H. L. ROACH ON MARKETING AND PROMOTION PROBLEMS

Thank you very much, Dr. Senti. Time is getting late and I want to say just a few words.

This conference has impressed me, as other conferences have, that there are so many facts in life that we find untrue. I think we have demonstrated that in this conference. This meeting has been most valuable to the Soybean Council in carrying on our market development activities because many questions were answered here, that we have been asked before and were unable to answer with authority. One or two comments and I'm through. I think some one said on this program that we didn't want to talk about products or display products to other people of the world that were unavailable to them, for this caused frustration. Listen, I've been frustrated a good many times in life. Unless somebody had told me about television and demonstrated it, I never would have bought one. I had to have a desire created for a television set and I had to go without other things to have one. I have observed in market development work that we don't need to worry so much about creating frustration. Our purpose is to create a desire for products. If desirable, people will endeavor to obtain them. People in other parts of the world are trying to crawl up the economic ladder a little bit to get the things we tell them about. So, while I think it's fine to have the goal of local production and have commodities cheap, I believe that incentives are extremely important in many, many countries that I've visited. We give them something to reach for and when we create desire, we put the burr under the saddle, so to speak, and we get a little action. My heart bleeds for some people that they can sit down, lacking desire and never bestir themselves trying to improve themselves any. So I think the job we have in market development work is to try to create a desire on the part of many people for better things of life.

In conclusion let me say that this conference has been a most helpful thing to we people engaged in market development work and not for soybeans alone. Because as we discover the truths about our commodities we can go out with confidence and say, "Our product is thus and so, it will do this." I hope nobody took too seriously what I said about using the name milk. There are some things that we just have to be careful about. I'll let you in on another secret. I am going up to attend the American Meat Institute meeting in Chicago tomorrow to see if I can allay the fears of some of my packer friends who are concerned that soybeans are going to supply all the protein in the diet of the American people. Now, I'm not worried, as a farmer and producer of livestock, very much about that. I think that as long as people can afford meat, they're going to have meat and then they must step down a level and then they'll have

what they can afford. I have always been amazed at the poor nation of Israel, and a few years ago at the poor nation of Spain, but they both have finally come up the ladder a little bit. Back in the depression it was my poor neighbors and I that were so poor but by the time a lifetime has elapsed we have come up the economic ladder a long way. I think that this is the thing that we in market development work have to do; create desire and help lift the standard of living. I've told the people in Spain for several years that the biggest export they have is olives, and yet they have never, until very recently, established an office for the sale of olives here in the United States. I tried to get them to start a promotion for two olives in every martini. You have to go out and create a desire on the part of people for commodities, and lo and behold Spain now has an office and you've seen within the last year advertisements in the Reader's Digest and some other magazines about olives. The olive people really got on fire about sales and they're really selling olives. I think the thing we did in selling soybean oil to Spaniards has given them ideas. Now, I'm working another one in Spain. I tell them on any crossroad store in the U. S. you can buy a Browning shotgun that is made in Belgium. Now they have great armorers in Spain; they make beautiful guns. But you've got to go to Spain to buy one. Well this takes time, but we can't sell to other people in the world unless they sell to us. After all we exchange goods. And so we're dedicated to find out what we can take from these people in payment for what we have to give them.

V

SUMMARY REMARKS ON RESEARCH IMPLICATIONS AND PROBLEMS

By Dr. F. R. Senti

Dr. Darby has pointed out areas where additional knowledge is needed to combat nutritional deficiency problems more adequately, especially for improving infants' and children's diets. He has particularly emphasized that we need to apply the information we already have on soybean products and processes to attack these problems. I join Dr. Darby in emphasizing the need for recognizing the advances that have already been made toward realizing the maximum potential of soybean products as a source of protein for human food.

The 21 papers and 2 panel discussions presented at this conference show that we have bland soy flours that can be used to prepare high-quality soy milks or emulsion-type foods and protein-rich cereal foods such as bakery products, spaghetti, and macaroni. In addition, soy flakes may be wet-processed to give either isolated soybean protein or protein concentrates of proven high-biological value. Wet-milling processes developed in the Orient produce a tasty soy curd, known as "tofu." We had the opportunity last evening to sample some of the fermented soy products--tempeh and miso, as well as tofu. Certainly these foods so widely used in the Orient have a place in other areas of the world for supplying needed protein.

There is opportunity, however, for research to contribute further in improving these products and especially to improve the technology for producing them. For example, in the case of soy milk, the data that has been presented by Drs. György and Fomon showed that several soybean milk products are suitable for feeding babies but the nutritional values of the products vary. Drs. Miller and Hand pointed out that soybean milk has been produced for many years, but yet we have no standardized method of production, no standards of quality. In this country, companies which are producing soy milk products have solved some of the problems of formulation to produce a high-quality product. The need is to make such information generally available and in a form in which the countries that are going to use these milks can apply it. We can anticipate that further research on soy milk, relating its composition to the method of processing and its nutritional value, should lead to standardized methods of production that meet the need, which Dr. van Veen expressed, of designing larger plants for cities or towns and smaller plants adapted to the requirements of a village population.

In the area of fermented foods, Dr. Hesseltine and Dr. Steinkraus pointed out that miso, soy sauce, natto, and tempeh are all products that have been developed over the years in the Orient without the benefit of modern research methods. Little experimental work has been done to determine their nutritional value, but the long experience in the Orient strongly indicates their value. Little is known

about changes in composition which are brought about by the fermentation. Dr. György reported the most interesting observation that genistein is liberated from its glucoside in the tempeh fermentation. Moreover, he reported that genistein is a powerful antioxidant that accounts for the unusual stability of soy oil in tempeh. This observation obviously may have further application and suggests that, as we understand better what goes on in these fermentation products, we will be able to improve the foods and simplify the processes for making them.

Then comes the important problem of stabilizing soybean food products to increase storage life, particularly wet products such as fermented foods like tempeh, and other products like tofu and soy milk. Generally, of course, refrigeration is not available to householders and food dealers in many of the developing countries, so there is need to develop a technology for drying or otherwise stabilizing these soybean foods. Their centralized production, storage, and distribution would thereby be improved and simplified. Such dried products must, of course, reconstitute with water satisfactorily.

In the area of complementing cereal foods, I was greatly impressed with the data that Dr. Huge and Mr. Diser presented. Certainly soybean protein admirably complements cereal protein to supply a better balance of amino acids than either protein alone. Combining the two is a method to be used and to be promoted, but, as soy flour is added beyond the 10-, 20-, and 25-percent levels, the problem of functional properties may be encountered. Mechanical properties of doughs, water absorption, and texture of the finished product may be affected, and so may be other properties such as color and flavor. The interaction of soy flour or soy protein with the components of cereals which affect functional properties depends partially, at least, on the extent of denaturation; hence, research may contribute by elucidating the precise nature of this interaction.

So far, we have relied mainly on moist heat treatment to nullify antinutritional effects that appear in raw soybeans. Heating is an effective and simple treatment. It is, however, always accompanied by protein denaturation and other changes which may be undesirable from the viewpoint of functional properties. As we isolate, characterize, and understand the properties of the antinutritional factors, the basis for developing processes other than heating for neutralizing them may be developed.

The problem of flavor alone is a very important one. We heard repeated references to flavor and its relationship to acceptability. Undoubtedly much of the concern about flavor arises from experiences with improperly processed products which had very poor acceptance. We know that steam treatment removes the undesirable "beany" flavors and gives a bland flour, but, at the same time, it denatures the proteins and changes their functional properties which are important in many uses but are of no concern in others.

As we go further into the details of soybean composition, there comes the question of the carbohydrate constituents and their contribution to properties of soy foods. In spite of the years of research on soybeans, relatively little is known about the carbohydrate constituents of soybeans. We have initiated basic studies on the composition and characterization of polysaccharides of soybeans, as you heard Dr. Hilbert say, with Dr. Hirst at the University of Edinburgh in Scotland. More than carbohydrate composition will need to be known, however. There is the problem of the function of the carbohydrates in processing as they relate to the development of color and flavor, as well as texture in food products.

One last facet, which is of great concern in processing soybeans for any food product, is the effect processing has on biological value of the protein. What is the effect on digestibility of the protein and the availability of the essential amino acids? In developing processing methods there is need for rapid tests to correlate processing variables with biological value of the protein. We heard from Dr. McGinnis about the dye-binding test for measuring basic amino acids. Better tests of this kind are needed for not only the lysine, a basic amino acid, but also for methionine, tryptophan, and others. Such rapid methods not only would facilitate development of new and more efficient processing methods but also would afford better control of quality in the production of soy products.

In concluding, I must express my thanks and appreciation to all participants for making this a stimulating and informative conference. To apply present knowledge and to extend this knowledge in supplying needed protein with soybean food products to meet well-recognized protein deficiencies involves exporting technical "know-how," as well as soybeans and soybean products, and requires extensive cooperative efforts by industry, government, university, and United Nations groups. That such cooperation can be attained has been ably demonstrated by this conference.

Conference on

SOYBEAN PRODUCTS FOR PROTEIN IN HUMAN FOODS

List of Attendance

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